From the cockpit: the P-51 Mustang

AIR&SPACE

$3.50

Smithsonian June/July 1991

Red Planet Road Test

How to walk, roll, hop, or crawl on Mars

Jimmie Angel's lost gold

Are big changes in store for pilot training?

06

0 73361 64757 3

Experience the thrill of aviation histo

Smithsonian History of Aviation Series

This series, edited by Von Hardesty, is intended to contribute to the overall understanding of the history of aviation.

Benjamin O. Davis, Jr., American
An Autobiography

From his first airplane ride at age 14, Benjamin O. Davis, Jr., knew he wanted to be a pilot. The future three-star general was determined to not let color stand in the way. The first black to graduate from West Point in the 20th century, Davis led the all-black Tuskegee Airmen into pivotal World War II combat that helped end the German occupation of Italy.
55 b&w illus. 480 pp.
Cloth: 0-87474-742-2 $19.95

A Dream of Wings
Americans and the Airplane, 1875–1905

Tom D. Crouch
"Such names as Octave Chanute, Samuel Pierpont Langley, Gustave Whitehead, August Herring, and Orville and Wilbur Wright are given life as the author details their individual creation of aviation as we know it today."—*Kitplanes*
65 b&w illus. 352 pp.
Paper: 0-87474-325-7 $17.50

Zemke's Stalag
The Final Days of World War II

Hubert Zemke as told to Roger A. Freeman
The story in this book on premier ace Hub Zemke's experiences on the ground as a prisoner of war in charge of nearly 9,000 POWs is as extraordinary as his adventures in the sky, where he broke all records for German planes destroyed in the air.
55 b&w illus. 164 pp.
Cloth: 1-56098-018-4 $21.95

Flying Tigers
Claire Chennault and the American Volunteer Group

Daniel Ford
This comprehensive history of the Flying Tigers recounts the exploits of the unorthodox and fearless group of pilots who challenged the Japanese in Burma.
Sept. 23 b&w illus. 480 pp.
Cloth: 1-56098-011-7 $24.95

Red Phoenix
The Rise of Soviet Air Power, 1941—1945

Von Hardesty
"A brilliant study of Soviet military airpower from 1941 through the end of the war."
—*Washington Post Book World*
"An excellent survey."—*Air University Review*
Sept. 136 b&w illus., 9 maps 288 pp.
Paper: 1-56098-071-0 $19.95

Lightning Over Bougainville
The Yamamoto Mission Reconsidered

Edited by R. Cargill Hall
Marshaling the recollections of American and Japanese World War II aviators, *Lightning Over Bougainville* addresses the military, political, ethical, and historical issues of the famous and controversial special operation that shot down the bomber carrying the commander-in-chief of the Japanese Combined Fleet.
50 b&w illus. 176 pp.
Cloth: 1-56098-012-5 $21.95

Howard Hughes and TWA

Robert W. Rummel
Written by a former TWA executive and close associate of Hughes, this book provides a unique perspective on this turbulent time in the history of aviation as well as a close-up view of Hughes's personal and business practices.
59 b&w illus. 480 pp.
Cloth: 1-56098-017-6 $29.95

Russian Lindbergh
The Life of Valery Chkalov

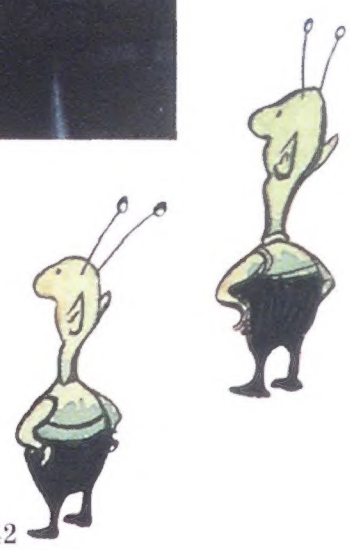
Georgiy Baidukov
Translated by Peter Belov
Edited and with an introduction by Von Hardesty
Originally published in Russian in 1975, this biography captures the life of the "Soviet Lindbergh" who piloted the first long-distance flight over the North Pole from Moscow to Vancouver, Washington. Written by a member of the transportation crew, the book portrays Chkalov as an emblematic hero for the new Soviet Russia.
Sept. 27 b&w illus. 352 pp.
Cloth: 1-56098-046-X $29.95

June/July 1991
Volume 6, Number 2

AIR&SPACE
Smithsonian

Contents


24


42


50


78

Cover: Creatures from the world of illustrator David Clark check out the latest in Mars rovers.

Departments

AIR & SPACE/Smithsonian (ISSN 0886-2257) is published bimonthly by the Smithsonian Institution, 900 Jefferson Drive, Washington, DC 20560. Subscription price: $18 a year in U.S. possessions, $24 elsewhere. Eighty-five percent of dues is designated for magazine subscriptions. Single-copy price: $3.50. Second-class postage paid at Washington, DC, and additional entry points. Editorial offices: 370 L'Enfant Promenade SW, 10th Floor, Washington, DC 20024. Advertising and circulation offices: 420 Lexington Ave., New York, NY 10170. Members: Address all subscription correspondence and change-of-address information to P.O. Box 53261, Boulder, CO 80322-3261. Postmaster: Send address changes to *AIR & SPACE/Smithsonian*, P.O. Box 53261, Boulder, CO 80322-3261.

The Lightweight A-2 Flying Jacket

The famous piece of battle gear now in 100% cotton for spring, summer and fall.

CALL TOLL-FREE:
1-800-367-4534
Ext. 635-100

The Jacket of Heroes.

The A-2 Flying Jacket is the most famous piece of battle gear in history. During World War II, the brave pilots of the U.S. Army Air Forces relied on the A-2 for protection and comfort. Whether in the cockpits of P-38 Lightnings over Europe, or P-40 Warhawks over China, the A-2 Flying Jacket identified its wearer as one of an elite, brave breed of fighting men.

From the Official Supplier of the U.S. Air Force A-2.

The U.S. Air Force recently recommissioned the A-2 for its pilots, and selected Cooper Sportswear, supplier of A-2's in World War II, as the official contract manufacturer of its leather A-2's. Now, the "Jacket of Heroes" has been re-created for you by Cooper in comfortable 100% cotton. Perfect for spring, summer and fall wear. The Lightweight A-2 Flying Jacket features authentic details including genuine leather snap-down collar, shoulder epaulets, roomy snap-closed pockets, and knit cuffs and waist band.

Payable in Monthly Installments.

The Lightweight A-2 Flying Jacket can be yours for just $119*, payable in four monthly credit card installments of $31.63. Your satisfaction is guaranteed. If you are not completely delighted with your jacket, simply return it in original condition within 30 days for exchange or refund. Available in authentic Desert Tan or Olive Drab. Sizes S, M, L and XL. Phone orders shipped within 1-3 weeks. Own a piece of history. Order today.

*Plus $7.50 shipping/handling.

Willabee & Ward
47 Richards Avenue
Norwalk, Conn. 06857

WILLABEE & WARD W&W

Satisfaction Guaranteed

CALL TOLL-FREE: 1-800-367-4534 Ext. 635-100

Please send me the jacket(s) I have indicated below. Fill in quantity and size: S(36-38), M(40-42), L(44-46), XL(48-50) in space provided:

_____ Qty. _____ Sizes(s) Desert Tan Lightweight A-2 Flying Jacket(s).

_____ Qty. _____ Sizes(s) Olive Drab Lightweight A-2 Flying Jacket(s).

For each jacket, charge 4 installments of $31.63** to my credit card.

☐ MasterCard ☐ VISA ☐ Discover ☐ Amer. Express

_____
Credit Card Number Expiration Date

Name _____
(Please print clearly)

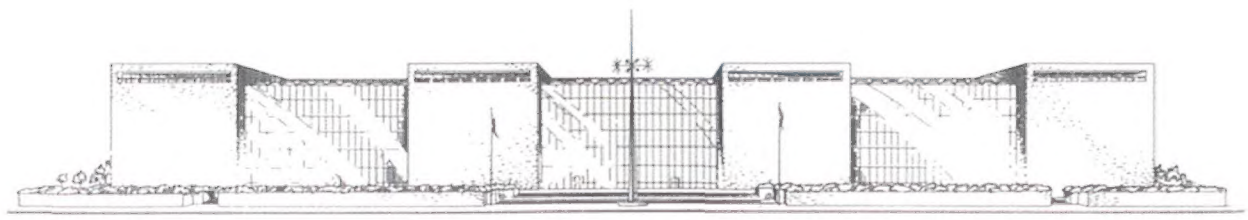
Address _____

City/State/Zip _____

Signature _____
(All orders subject to acceptance.)

☐ I prefer not to use a credit card and will pay by check. Enclosed is my check for $119 plus $7.50 shipping/handling, a total of $126.50** for each jacket.

**Any applicable sales tax will be billed with shipment.



Smart Versus Nuclear Bombs

In the early days of World War II, U.S. air power doctrine aimed at destroying an adversary's ability to wage war by destroying his military production and supply system. This meant strategic bombing targeted specifically at aircraft factories and armament industries crucial to providing the machinery of war, and later concentrated on oil refineries and munitions factories required to keep that machinery in action and on bridges and railroad junctions essential for supplying those resources to fighting men.

In the course of the war, the British rejected this doctrine, and the United States silently allowed it to lapse, as thousand-bomber raids first devastated whole cities in Germany and later leveled most of the major population centers in Japan. In the face of fighters and flak, precision bombing turned out to be almost impossible. At the start of the war, a typical bomb fell up to three miles away from its intended target in daytime and up to five miles away at night. Toward the end of the war, that circle of error had been reduced to about a thousand yards. But that still meant devastating a whole square mile of a city in order to be certain of destroying a single important military target. And it took vast fleets of bombers to fully cover that big an area.

The crews in those armadas of bombers suffered horrendous losses, particularly over Europe, in the early days of the war, when German fighters, day after day, night after night, rose to attack and destroy the unescorted, heavily laden, lumbering aircraft. Only in the last 18 months of the war in Europe were long-range fighter escorts available to keep German attackers at bay.

These difficulties made the atomic bomb developed at Los Alamos, New Mexico, seem like an incomparably more efficient weapon. It could be delivered by a single airplane and was capable of immense destruction. And within a few years after Hiroshima and Nagasaki, military doctrine began to evolve in the direction of huge nuclear arsenals.

A challenge to the nuclear doctrine may now have been offered up by the war in the Gulf. The smart bombs employed there showed a remarkable ability to hit individual buildings and even rapidly moving tanks, while keeping civilian casualties substantially lower than in any previous wars of comparable magnitude.

In effect, the war in the Gulf returned to the original doctrine of concentrating on military targets and showed that the doctrine could now be successfully implemented in combat.

If we genuinely adhere to this revived doctrine and its greater concern for minimizing casualties among civilian populations, how do we deal with the huge nuclear arsenals amassed over four decades of cold war? It makes no sense to target a nuclear weapon for delivery to a single building or even a tank battalion. These weapons of mass destruction vaporize, rather than merely destroy, the intended target, and they wipe out large surrounding regions as well.

If smart weapons can so successfully take care of all purely military requirements, are nuclear weapons to be kept in our arsenals only to pose a nihilistic retaliatory threat to any enemy contemplating first use? And if so, how many such weapons would we need to retain for adequate defense?

Answers to such questions will not be found quickly. Military analysts will need to think through all of the ramifications of the Gulf war before deciding on a new nuclear strategy. But if that strategy were to involve a dramatic reduction of the world's nuclear arsenals, all of us would breathe a little easier for our children and grandchildren.

Wars inevitably claim innocent victims. If the lessons learned from the Gulf war could enable us to lower the nuclear threat that has hung over the world now for nearly half a century, we would at least have gained something from all those "smart" bombs besides just one more set of sophisticated weapons.

—Martin Harwit is the director of the National Air and Space Museum.

AIR&SPACE
Smithsonian

Secretary of the Smithsonian Institution
Robert McC. Adams

Editor
George C. Larson

Managing Editor
Tom Huntington

Senior Editor
Linda Musser Shiner

Picture Editor
Lee Battaglia

Departments Editor
Patricia Trenner

Associate Editors
Karen Jensen
David Savold
Diane Tedeschi
Perry Turner

Design Consultation
Phil Jordan
Julie Schieber

Associate Editor/Pictures
Caroline Sheen

Publisher
Ronald C. Walker
Mary D. Haskin, Assistant

Administration
Carey O. Randall, Associate Publisher

Advertising
Louis C. Kolenda, Director
Maurice Casey
Donald Cataldi
Edward Proshuto

Circulation
Gale Page, Director
Margaret Moore
Paula J. de Brito

Production
Sarah D. Kingsley, Manager
Kristine L. Roberts

Business
Shelia Perry Brannum, Manager

Founder
Walter J. Boyne

Publisher Emeritus
Joseph J. Bonsignore

THE AUTHENTIC INSIGNIA PATCHES OF THE FIGHTING UNITS OF

★ OPERATION DESERT STORM ★

Your First Patch JUST $9.95!

U.S. Army First Cavalry Division 3⅞" x 5¼"

Second Marine Division 2⅝" x 3⅞"

U.S.A.F. 37th Tactical Fighter Wing 3" x 3"

First Armored Division 3¾" x 4"

First Infantry Division ("The Big Red One") 2½" x 3¾"

101st Airborne Division 2⅞" x 3½"

Battleship USS Missouri ("The Mighty Mo") 4" x 4⅞"

Operation Desert Storm, the most decisive military campaign of our lifetime. Now, you can own the official embroidered insignia patches of the victorious American fighting units of Operation Desert Storm.

The First and Second Marine Divisions, spearheads of a relentless drive through Saddam's front lines. The lightning-fast 101st Airborne, outflanked the enemy before they knew what hit 'em. The 37th Tactical Fighter Wing, the elite Stealth Fighter unit, wreaked havoc with its devastating precision. The USS Missouri, "The Mighty Mo," pounded Iraqi positions with her 16 inch guns and cruise missiles.

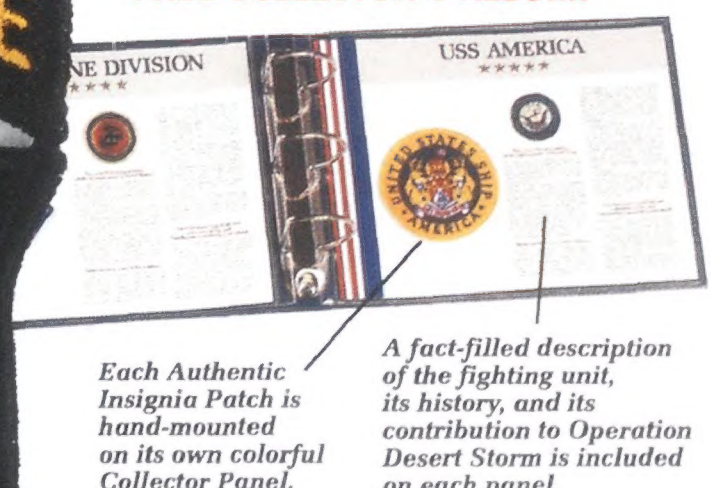
You'll receive all these and many more! Each patch is a unique, authentic, embroidered design mounted on a deluxe Collector Panel detailing the complete facts about the unit: manpower, armament, accomplishments, and history. What's more, an elegant Collector's Album is included at no additional charge.

Exclusively from Willabee & Ward. Not sold in stores or catalogs.

The Collection is affordably priced, with a convenient acquisition plan. Your first patch mounted on a deluxe Collector Panel is just $9.95. Each month, you'll receive two patches each mounted on its own Collector Panel, priced at just $11.95 each, plus $1.45 shipping/handling per patch. For fastest service call toll-free. Normal shipment on phone orders 3-6 weeks. Order today!

CALL TOLL-FREE: 1-800-367-4534
EXTENSION 629-101

FREE COLLECTOR'S ALBUM!



Each Authentic Insignia Patch is hand-mounted on its own colorful Collector Panel.

A fact-filled description of the fighting unit, its history, and its contribution to Operation Desert Storm is included on each panel.

Panel shown much smaller than actual size of 9" x 12".

RESERVATION APPLICATION

Willabee & Ward
47 Richards Avenue
Norwalk, Conn. 06857

Satisfaction Guaranteed

CALL TOLL-FREE: 1-800-367-4534 EXT. 629-101

Yes! Please reserve for me **The Authentic Insignia Patches of the Fighting Units of Operation Desert Storm.** After receiving the first patch at the introductory price of just $9.95*, I will receive two patches per month and pay just $11.95* per patch (plus $1.45 shipping/handling per patch). A deluxe Collector's Album, shipped after payment for my third patch is received, will be provided at no additional charge. I understand that I may return any patch within 30 days of receipt for a full refund and that either party may cancel this subscription agreement at any time.

Name_____
(PLEASE PRINT CLEARLY)

Address_____

City/State/Zip_____

Please charge my patches to my credit card upon shipment.
☐ MasterCard ☐ VISA ☐ Discover ☐ Amer. Express

Credit Card# Exp. Date

Signature_____
(All orders subject to acceptance)

☐ I prefer not to use a credit card and will pay by check. Enclosed is my check for $9.95*, payable to Willabee & Ward, for my first patch. Bill me for additional shipments.

*Any applicable sales tax will be billed with shipment. Allow 3-6 weeks after initial payment for shipment.

Letters

Life on Mars

We should all be deeply troubled by the dogmatic "no life on Mars" view prevalent among influential exobiologists ("The Case for Life on Mars," February/March 1991). Already there is talk of cutting costs on future Mars missions by launching unsterilized spacecraft. Given the incompleteness of the data available, this action would be unconscionable and would seriously jeopardize our ability to determine whether indigenous Martian life-forms exist. Gil Levin should be commended for his unwillingness to jump on the "no life" bandwagon, which has no regard for what may get trampled underneath its wheels.

José J. Valdés
Boynton Beach, Florida

I thought scientific research was meant to look at all the possibilities. The results of the Viking missions concerning life are inconclusive, yet some scientists say that life on Mars does not exist, period. These scientists are going by a set of rules based on life on Earth—carbon-based life. Those who do not welcome the opportunity to confirm their initial findings with the latest technology are not true scientists.

If we look at the history of science, it has been a constant cycle of confirming and refining our understanding of the world. If we close our minds to any of the possibilities, then we have defeated our very purpose for searching in the first place.

Claude Hubert
Lynnwood, Washington

Imperiled Pyramids

I find "Rally 'Round the Pharaohs" (April/May 1991) incredible. How could the Egyptian government permit these unpredictable ultralights to operate near the pyramids? The failure of one of these aircraft could have done incalculable

damage to priceless structures. I am surprised that *Air & Space/Smithsonian* would support such desecration by advertising its existence. I almost discontinued my subscription.

Warren G. Smith
Gainesville, Georgia

Landing a Blimp

I graduated from the U.S. Naval Airship Training School in 1939 and flew in blimps over the West Coast during World War II. From the photographs in "The Blimp Bowl" by John Grossmann (February/March 1991), I can see that the instrument panel appears to be somewhat more high-tech, but today's blimps still look pretty much like those I flew 40 years ago.

In the story, Grossmann says that pilot John Moran "throws the props into reverse" when he lands. I have been involved in many blimp landings and cannot recall ever needing to reverse the engines to prevent forward movement of the blimp when landing in high-wind conditions. Most likely Moran reversed only one engine, which would give him some measure of control (forward and reverse) while the ship was being put on the mast. Not to be picky, but in the old days the statement "cut your engines" meant to stop them, not idle them.

H.T. Chambliss Sr.
Mountain View, California

John Grossmann replies: I am happy to report that we are both correct. I spoke with John Moran, who said that Chambliss' landing method would indeed have been appropriate had there still been 30-mph winds at the airport near the ground. The windspeed at the time of landing was probably about half that. Says Moran, "I used a little reverse to be exact, considering the small amount of space we had to bring the ship to mast."

High-Altitude Prayers

"The Height of Ambition" (April/May 1991) brought to mind a lecture Albert Stevens gave in his hometown of Belfast, Maine, soon after his historic flight in *Explorer II*. Though much scientific equipment was eliminated before the flight, Stevens and Orvil Anderson were at times so busy piloting the balloon that they were oblivious to all else. Murphy's Law may have resulted in certain outcries not intended for broadcast, which in fact flowed through an open mike to the many spectators listening on the ground. Stevens told us that after he had landed, a little old lady told him that she knew he must have flown high because she heard him talking to Jesus.

Raymond E. Hills
Winterport, Maine

Airshow Autopsy

I am angered by Stephan Wilkinson's account of the death of test pilot John Derry while flying a de Havilland 110 at the 1952 Farnborough airshow ("Mach 1: Assaulting the Barrier," December 1990/January 1991). I was one of 300 Royal Air Force personnel who miraculously survived the engine plowing

through our midst on the side of that Farnborough hill and who instantly formed a human barricade to enable emergency workers to perform their harrowing task unhindered by ghoulish curiosity seekers. I am disgusted by the implication that such a fine gentleman and professional pilot as John Derry was deliberately attempting to produce a bang directly at the crowd.

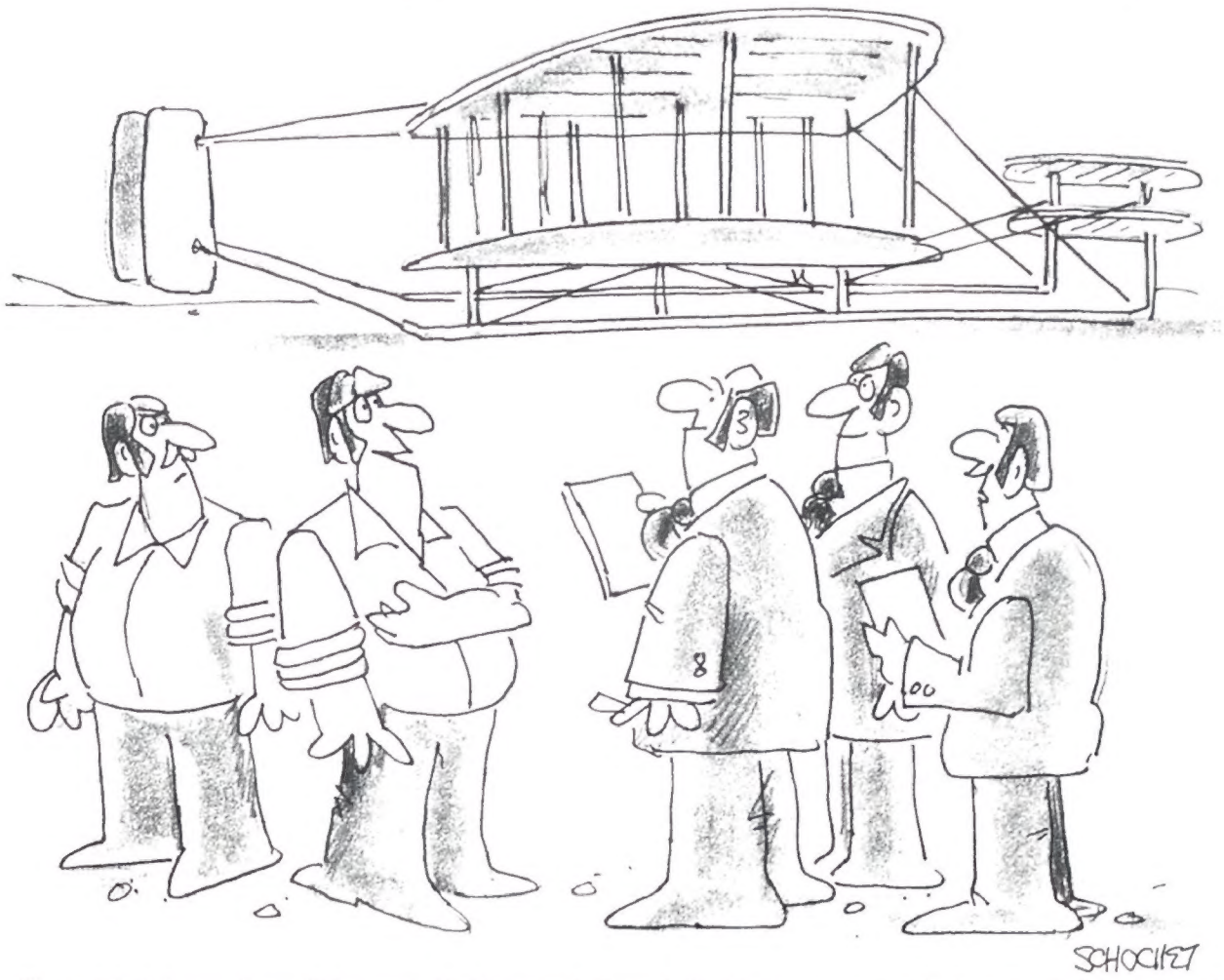
Immediately prior to the crash Derry was making a rolling pullup, and on thinking back, I estimate his speed to have been about 400 mph. We saw pieces suddenly coming off the aircraft and at first thought it was a flock of birds. But a split second later the machine broke up, the center pod hitting the ground and disintegrating on the grass in front of us.

John Derry was most definitely *not* trying to cause a bigger boom than the one that heralded his arrival over the field. He had made a low-level 360-degree turn in front of the crowd and was rolling out and up when the failure occurred. Some years later a de Havilland engineer told me that the breakup was partly due to the removal of the temporary wing fences, which, though not recognized at the time, provided some measure of resistance to buckling of the wing leading edges. Because someone had neglected to provide leading edge shear webs, the leading edges of even such a high-performance machine would buckle. Failure of both outboard wing panels and their subsequent departure caused the aircraft to pitch sharply upward. Then other parts of the machine became overloaded, failing in quick succession. The gentleman who explained the findings to me went on to describe John Derry in quite emotional terms and was vociferous in his praise. I got the impression that they were quite close. I find it very unjust that your writer should have painted this brilliant test pilot with less than flattering implications.

Jim Newman
Hobart, Indiana

Stephan Wilkinson replies: The basic information for my recounting of John Derry's Farnborough crash came from the British book Supersonic Flight *by Basil Clarke, who gives the following account: a great feature of postwar Farnborough displays was the creation of sonic booms, usually by an airplane that dove through Mach 1. The trick—increasingly perfected by the Brit show pilots of the time—was to throw the boom at the crowd, flying toward the crowd line and through Mach 1 at just the right time. This tradition ended in disaster, says Clarke, when Derry pulled the DH-110 apart while he tried to make a bigger boom. One of the 110's engines went into the crowd, killing 28 and injuring 63.*

I have also seen a film of the accident. It seems pretty clear to me that if Derry managed to hit nearly 100 people with that engine, which obviously would have gone ballistic in the direction the airplane was flying when it came apart, he was ipso facto *flying straight toward at least one crowd. We'll never know for sure whether he was literally trying to make a bigger boom, and perhaps that was an unfair assumption on my part. But we do know three things for sure: (1) The course of his airplane was such that wreckage continuing along that course landed in a crowd viewing the show, (2) sonic booms were henceforth banned at Farnborough, and (3) flying display airplanes toward the crowd was also banned at Farnborough. The latter two restrictions are direct results of Derry's accident.*



"I couldn't have done it by myself. Some vital contributions were made by what's his name."

Official Superstition

Thanks for the poster celebrating the 10th anniversary of the space shuttle (April/May 1991). As a teenager who dreams of being an astronaut, it was uplifting to see the orbiter viewed as a work of art and not just the subject of budgetary debate. In reading your description of the poster, I noticed that you referred to the fatal *Challenger* flight as STS-25. According to U.S. Congressman Bill Nelson's book *Mission*, former NASA administrator James Beggs feared the number 13. After the successful launch of STS-9, Beggs demanded a new numbering system since the launch of the 13th flight was near. So STS-13 became STS41-C. The official number of the *Challenger* flight was STS51-L, not STS-25.

Susan Lynn Bariletti
Boca Raton, Florida

Editors' note: The new numbering system was based on the shuttle flight's fiscal year and launch location (either Kennedy Space Center in Florida or Vandenberg Air Force Base in California). When this proved too confusing and flights continued to be launched out of the order in which they'd been named, NASA went back to the old numbering system.

Aviation's Dark Side

I was struck by two points Martin Harwit made in "Truth in Labeling" (Viewport, April/May 1991). The first was the difficulty of finding corporate sponsors for Vietnam-era aviation exhibits, and the second was the conflict involved in contrasting military aviation's incredible accomplishments with its destructive purposes. Regarding the Vietnam exhibit, one benefit of the Gulf war may be a long-

WINGS OF GLORY

The definitive pewter sculpture of the U.S. Navy F-14 Tomcat.

Shown smaller than actual size of 8¼" in length. Scale 1:90.

It's a major triumph in the eternal fight for freedom! And this exciting commemorative sculpture will forever honor those who risked everything in freedom's cause.

Recapturing all the majesty and power of America's F-14 fighter jet, this dramatic symbol of superiority in the skies is packed with detail, from its missiles to its historic "swing wings" that can change configuration in mid-flight.

The issue price for this spectacular display piece: Just $195, payable in convenient monthly installments. Exclusively from The Franklin Mint.

Positioned on its own hardwood and metal display, this exciting sculpture soars dramatically skyward.

THIRTY DAY RETURN ASSURANCE POLICY

If you wish to return any Franklin Mint purchase, you may do so within 30 days of your receipt of that purchase for replacement, credit or refund.

Intricately sculptured, richly detailed.

Order Form

Please mail by July 31, 1991.

The Franklin Mint
Franklin Center, Pennsylvania 19091

YES! Please enter my order for the definitive pewter replica of the F-14 Tomcat. This spectacular imported display piece is to be hand-cast in pewter, handcrafted, and hand-rubbed to a full, rich patina.

I need send no payment now. I will be billed for my deposit of $39.* prior to shipment, and for the balance in 4 equal monthly installments of $39.* each, after shipment. The handsome hardwood and metal display stand will be provided at no additional charge.

**Plus my state sales tax and a one time charge of $3. for shipping and handling*

SIGNATURE _____ ALL ORDERS ARE SUBJECT TO ACCEPTANCE

MR./MRS./MISS _____ PLEASE PRINT CLEARLY

ADDRESS _____

CITY _____

STATE/ZIP _____

©1991 F.M. 14624-6

overdue recognition of the heroism of those involved in Vietnam and of the place they played in the overall development of aviation. Let us hope that corporate sponsors realize that the public is ready for this.

I have often heard friends say that although aircraft may be fantastic and the designers and pilots true heroes, there is still tragedy in their purpose. Many in the aviation community take one of two views on this. They either glory in the destructive power of military aviation or they ignore it, concentrating on the beauty and romance. The recent war in the Persian Gulf may suggest a more mature outlook somewhere in between. As we watched briefings that glorified our technology through sanitized film from gun cameras, cameras on the ground recorded the awful reality of mutilation and death that is war. And now we know that what for us was a short and relatively painless conflict will be for the civilians on the ground a lingering misery of chaos and disease.

Jerry W. Lewallen
Rothbury, Michigan

I feel compelled to cast my vote in favor of the honest approach being taken by the Museum in the labeling of its displays. My position is based upon the adage "He who fails to remember history is condemned to relive it." The "V" weapons that Harwit cites were responsible for the indiscriminate destruction of many lives, and this fact should not be lost due to historical indifference.

Paul L. Day
Parma, Ohio

The Shuttle's Shortfall

I must take exception to your view of the space shuttle in "About the Poster" (April/May 1991), which states that "the program has suffered setbacks, but overall the space shuttles have performed remarkably well." I would like to remind you that when the shuttle was sold to

Congress and the American people, NASA said that the shuttle would be capable of flying 60 missions a year. Now, after 10 years, the shuttle has yet to fly a total of 40 missions. NASA must take an unemotional look at the shuttle and ask itself if the shuttle's cost could be better spent on expendable booster technology.

Anthony E. Grass
Burlington, Vermont

Editors' note: See "Beyond the Shuttle" on page 62.

Happy Anniversary

Well, you have done it again. Each issue of *Air & Space/Smithsonian* seems to outdo the previous one. As an old retired bird (World War II combat fighter pilot with 35 years as a test pilot), I begin drooling when I find *Air & Space* in the mailbox. I usually dole the articles out over some time to make the enjoyment last as long as possible. But when the April/May 1991 issue arrived, I sat down and read the thing in one fell swoop. The combination of diverse, well-written articles and breathtaking photographs is an art that simply shoots every other aviation publication right out of the sky.

H. Dixon
Irvine, California

Correction

Robert F. Reiland's letter remembering F-100 test pilot George Welch is a valuable addition to the memory of this daring man. However, as a Marine pilot who flew Corsairs in Korea, I am prompted to remind him that the Chance-Vought F8U is the Crusader, not the Corsair.

John W. Hatcher
Leawood, Kansas

Editors' reply: The name "Corsair" actually applies to the F8U's descendant, the A-7 Corsair II, so it's easy to see how the mental lapse occurred. In fact, the editors would have corrected the error, but the same thing happened to us.

Air & Space/Smithsonian *welcomes comments from readers. Letters must be signed and include a daytime telephone number. Letters may be edited. Write to* Air & Space/Smithsonian, *370 L'Enfant Promenade SW, 10th Floor, Washington, DC 20024.* Air & Space/Smithsonian *is not responsible for the return of unsolicited photographs or other materials.*

Will Rutan Racer Ravage Reno?

It was no coincidence that last April 4, Lyle Shelton happened to fly over California's Mojave Airport in the Grumman Bearcat *Rare Bear*, the world's fastest piston-powered airplane and five-time winner at the Reno, Nevada Air Races. That day at Mojave, a crowd had gathered to witness the inaugural flight of the Pond Racer, Burt Rutan's brand-new entry in the field of unlimited air racers. Knowing Rutan, the aeronautical engineer who designed the round-the-world *Voyager* and other radical aircraft, the onlookers were pretty sure that his new airplane wasn't going to look anything like the souped-up World War II fighters that always triumph at Reno's September race. It was this winning tradition that Shelton was there to remind them of.

Rare Bear came by for another deafening pass before Dick Rutan, the pilot of the *Voyager* and Burt's brother, whistled by in the Pond Racer, which consisted of two four-blade propellers followed by a pair of automotive racing engines, with Dick suspended between them toward the rear of the aircraft. Dick banked and turned the Pond Racer by the windmills in the Tehachapi Pass and flew tight circles for the spectators. They would be reminded over and over that Dick was running the low-speed flight test engines at a mere 40 percent of power. At Reno, the 1,000-horsepower racing engines would be run at 90 percent.

The Pond Racer began as a dream of Bob Pond, a former Navy pilot and owner of the Planes of Fame Air Museum in Minnesota, where he stables his 23 airworthy World War II aircraft. Pond was fascinated by air racing but reluctant to modify any of his vintage fighters to Reno-competitive standards. Three years ago he connected with the Rutans, and together they conceived the Pond Racer, based on the idea that modern technology and replaceable parts could boost air racing to the same level of popularity auto racing enjoys. They also wanted to set a record for piston-engine aircraft.

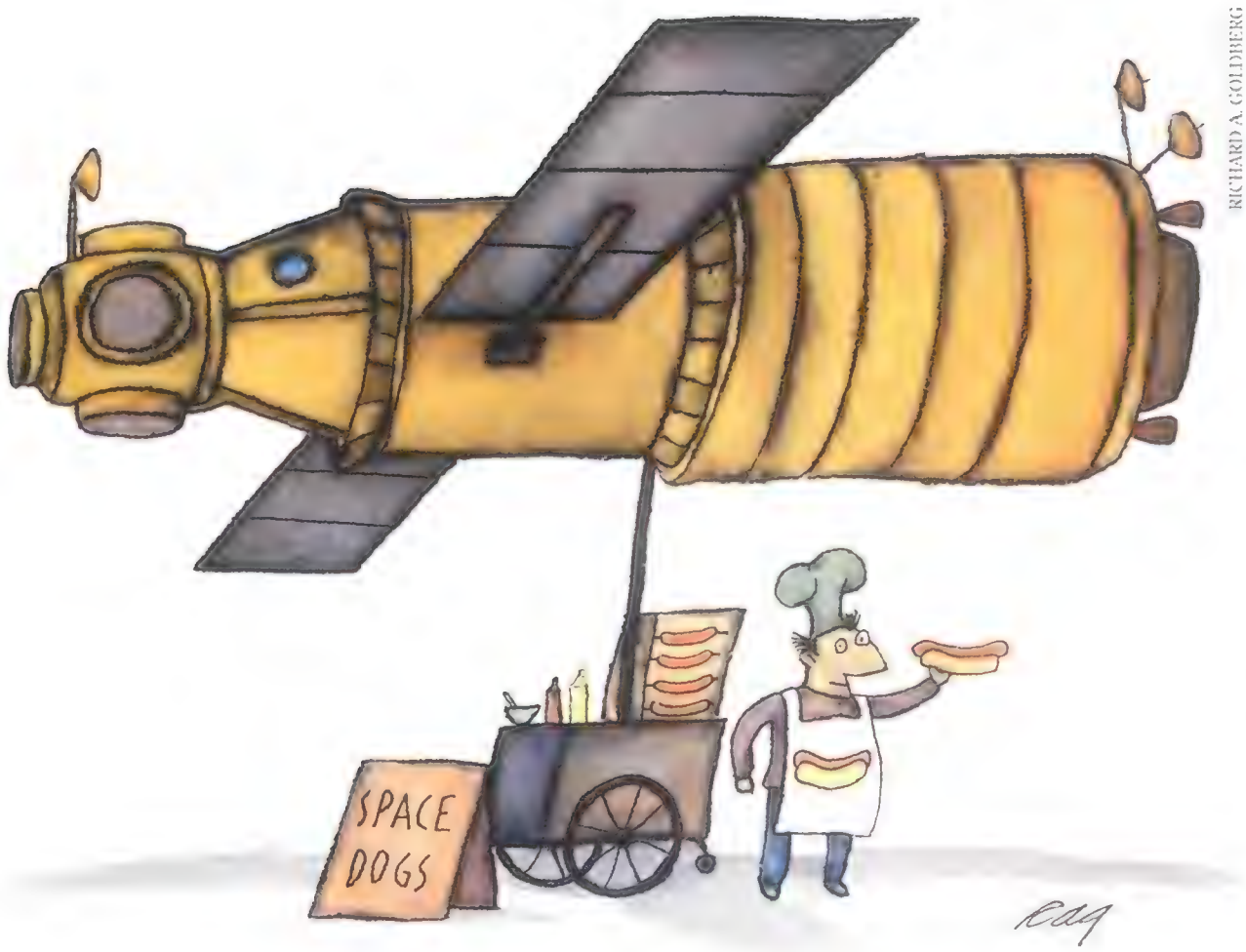
"The number that sticks in my mind as a design goal was 527 miles an hour," Burt told the gathering at Mojave. Then, looking straight at Shelton, he grinned and added, "I don't know if it was a coincidence that you went 528 [when Shelton set the existing record], but it did tell us that we needed to do more than we had originally planned."

Rutan began with a six-cylinder automotive engine that is manufactured by a small Southern California company called Electramotive and had proved successful on the auto racing circuit. Electramotive president John Knepp soon became an enthusiastic ally. It was his job to shoehorn each 170-hp engine, the turbocharger that would help boost it to 1,000 hp, and the gear box that drives the propeller all into a space two feet in diameter. "One of the things Burt always said was that if we could keep it real slippery, then it would go real fast," Knepp recalled.

Knepp's success with the little engines enabled Burt to keep the racer relatively small. "This airplane weighs nearly 4,000 pounds with fuel and pilot, ready to race," said Burt, "but it doesn't have any more wing area than a Formula One racer."

"Everything the *Voyager* was not, this

RICHARD COX



RICHARD A. GOLDBERG

one is," Dick added. "It's a very light, nimble airplane." So far he's flown it to 360 mph. "Once this party's over," he said, "we're going to push the power right on up and find out what kind of race vehicle we have." At 900 hp per engine per side, Burt thinks the Pond Racer will fare well in the Unlimited category at Reno. "After that," he said, "we plan to run more power out of the engines, up around 1,000 horsepower, and bring the plane up to 540 miles an hour and attempt a new world speed record for piston/propeller-class airplanes."

Shelton didn't appear to be worried. He stood watching the Pond Racing Team disconnect the hoses and fans that had cooled the engines after the inaugural flight. "I think it will be exciting competing with these guys," he said. Then he nodded toward *Rare Bear*, parked on the ramp. "But we can squeeze another 20 to 25 miles an hour out of that short, fat, stubby thing. And if we do that, they may never beat us just because of our brute horsepower and ugliness."

—Elaine de Man

Mock-up on the Block

Space Commerce Corporation, the Texas company behind the recent failed effort to send an American for a ride on the Soviet space station Mir, has a new deal. The firm now wants someone—*any*one—to buy a Mir replica that will be displayed at this summer's Paris Air Show by the Soviet space agency Glavkosmos.

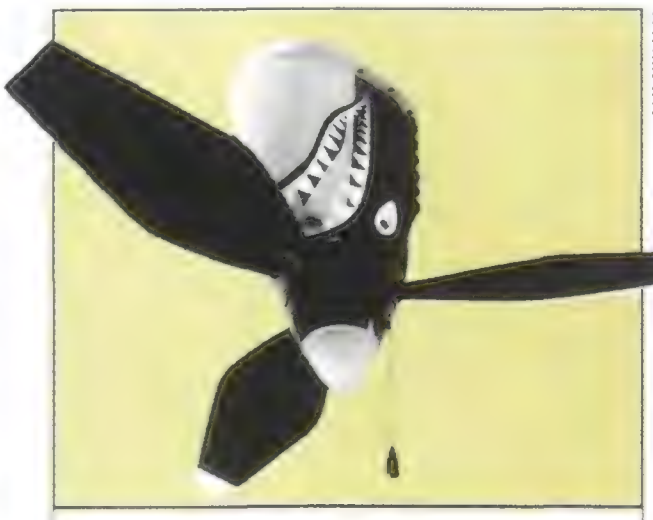
"The first guy that gets a check for $10 million to me is going to own a space station," says Space Commerce president Art Dula. That's the price for four modules—the cornerstone and three additions—outfitted with spare equipment. "This was actually built by the factory that built the [operating] Mir space station," Dula points out, "and all the elements on it are real. They just haven't been qualified for space."

Assembly is not included, but Dula says experts from the Soviet Ministry of General Machine Building will be happy to add their two kopecks to help close a sale. Unassembled, the mockup fills a dozen tractor-trailers.

It's another experiment in capitalism for Glavkosmos and another marketing challenge for the Houston business, which sells everything from launches to lapel pins for the Soviets and splits the profits (see "Soviet Booster," February/March 1991). Dula is pitching this latest product at U.S. aerospace firms: "The highest value is as a technological mockup for someone to learn how to build a space station," he says.

But if the contractors don't bite, Dula says he won't worry. "I really think it has potential as a theme park or [for] a private collector," he says. "There are plenty of people who are rich enough to buy this."

—Beth Dickey



JAEGER USA

The Curtiss P-40 ceiling model is a real aviation fan. The first of the Jaeger USA Warbird Fans, the product is "sure to stir not only the air around it but the imagination of those who appreciate classic aircraft," the California company breezily promises.

Update

X-29 Excels

The Air Force-NASA X-29 completed its high-angle-of-attack testing last February at California's Edwards Air Force Base ("X-29," April/May 1988). The forward-swept-wing demonstrator achieved a 67-degree angle of attack and all-axis maneuvering up to 45 degrees. "This is a higher angle of attack than most supersonic aircraft can fly without vectored thrust," says Lieutenant Colonel William Gotcher, an Air Force program manager.

NASA's Boom Box

There's a boom going on at NASA's Langley Research Center in Hampton, Virginia—several thousand a week, in fact. But you won't notice them while strolling the facility's shady streets. Step into the Structural Acoustics building, the home of NASA's sonic boom box.

Langley has been studying the effects of aircraft noise on residential communities on and off for some 20 years. In the 1970s, engineers researched the effects of subsonic and supersonic aircraft noise by placing subjects in mock living rooms and backyard scenarios and

ASTRONAUTS MEMORIAL FOUNDATION

"Space Mirror," a memorial to the 14 U.S. astronauts who have died in the line of duty, was dedicated May 9 at the Kennedy Space Center in Florida. The 42- by 50-foot monument, faced with mirror-finished black granite, swivels to track the sun, and the light is reflected by mirrors through the names carved in the panels. Listed with the Challenger *and Apollo 1 crews are the four astronauts killed in T-38 jet trainer accidents. Funding for the $7 million memorial came from the sale of* Challenger *license plates, which was authorized by the Florida legislature.*

exposing them to recorded aircraft noise. But research priorities changed in the early 1980s and the NASA noisemakers went on to other projects. A new program started up in 1989, when researchers began studying community reaction to the noise of a proposed new generation of supersonic transports.

The Sonic Boom Simulator in the Structural Acoustics building is built of reinforced concrete and resembles a giant amplifier, reminiscent of the one that blew away Michael J. Fox in *Back to the Future.* The most difficult part of its construction, says project director Andy Powell, was persuading the contractor to drill eight holes in the door for the Audax and JBL speakers that transmit the booms.

Subjects in the box are subjected to about 200 sonic booms during a 20-minute session. The half-second booms aren't particularly noisy; the loudest resemble a kettledrum more than a jet aircraft. Listeners scribble their response to Concorde sonic booms as well as muffled booms designed to mimic future SSTs. For variety, the shorter-duration booms of fighters are added.

Powell expects the project to continue for at least two years. Plans include replacing participants' pads and pencils with computers and taking the loudspeakers on the road. Also in the works is a plan to surround a Georgia Institute of Technology house with speakers. Booms will be blasted while the occupants eat, sleep, and work.

While it's too early to surmise how the new booms will affect people, Powell says that an earlier experiment found that aircraft noise is less damaging to buildings than had been suspected. Monitors at Sully Plantation, a historic estate near Washington-Dulles

International Airport, documented that "vibrations inside the house, such as vacuum cleaners and people walking around," produced greater structural vibration than departing Concordes and DC-10s.

—Martin Morse Wooster

Update

Piaggio To Go It Alone

Piaggio has taken over the marketing of its P.180 Avanti from AMR, a division of American Airlines that had been charged with North American sales of the new twin-engine turboprop ("Piaggio," August/September 1988). Piaggio says it has fixed problems with the cockpit air distribution system and has increased the lower-than-expected payload weight.

CAROLYN RUSSO

American Junior Aircraft has resurrected the classic balsa airplanes that model builder Jim Walker developed in 1929. Before Walker's death in 1958, his company produced more than 235 million models, a great number of which were shredded by the machine guns of World War II gunners in training. Today, American Junior's small workforce in Portland, Oregon, handcrafts the hand-launched A-J 74 Fighter, the stick-launched A-J 404 folding-wing Interceptor, and the rubber band-powered A-J Hornet.

Update

Lighthawk Gets Heavy

Project Lighthawk, the flying conservation group based in Santa Fe, New Mexico ("Flight of the Lighthawk," August/September 1987), has added a 14-passenger de Havilland Twin Otter to its fleet of two single-engine Cessnas. Lighthawk will use the Otter to fly members of Congress, their aides, and celebrities over the Cascade Range in the Pacific Northwest in a campaign to curb clear-cut logging.

Behind Curtain Number 1

Borrowing a trick or two from Monty Hall, Virginia's Center for Innovative Technology and Orbital Sciences Corporation hosted a coming-out party—appropriately enough, on the first day of spring—for a tiny newcomer to the mobile communications scene. Hidden behind a silver lamé curtain, which hung in the center of the CIT lobby like a nightshade for a celebrity parrot, was Orbcomm X, a 35-pound satellite built to test Orbital Sciences' concept of a space-based message relay network. It's the latest product to spring from the fertile ground at Orbital Sciences, a Fairfax, Virginia corporation that conceived the airplane-launched Pegasus booster (see "Entrepreneurs in Space," December 1986/January 1987).

Scheduled for a May launch on an Ariane rocket, Orbcomm X confers on Virginia the distinction of being the first state in the union to orbit its very own satellite. On hand for the coming-out party was Lieutenant Governor Donald Beyer as well as former governor Linwood Holton, now president of CIT's board of directors. Headquartered near Washington-Dulles International Airport in a slick Arquitectonica-designed building that disdains right angles, CIT contributed $250 million to the construction and launch of the satellite. In return, Orbital Sciences gave time on the satellite's store-and-forward communications system to Virginia's state university researchers.

Over the next 18 months, Orbital Sciences will test the amount of broadcast frequency activity and transmission power levels needed to operate its planned

network of 20 mobile communications satellites. At the same time the universities will use the system for such experiments as monitoring the stress level of bridges and the temperature and salinity of the Chesapeake Bay. Then CIT and Orbital Sciences will explore the marketability of those uses of the system.

Orbital Sciences was the first of several companies to petition the Federal Communications Commission for a frequency for low-orbit small-satellite communications systems. The Starsys company wants to send up 24 satellites to provide message and location services primarily for the automobile and emergency-care markets, and Ellipsat has announced plans to launch a fleet of tiny comsats.

It's too early to say whether Orbital Sciences has a winner with this low-cost, pocket-portable system, but the mood at the party was sunny. Orbital Sciences CEO David Thompson, a Dean Jones lookalike who seems destined for a happy ending, made brief upbeat remarks in which he referred to northern Virginia as the Hollywood of the space business. Beyer pointed out that besides CIT and OSC, Virginia had given the nation Lewis and Clark and the Statler Brothers. A group of elementary schoolchildren, each polished to a high shine, was on hand to emphasize the cooperation between industry and educational institutions. And after Holton told them about the technology that would one day allow them to use a hand-held transmitter to send a message "anywhere on the whole planet," the children joined Beyer at the silver curtain and—to their genuine delight—cooperatively pulled the cord. The little briefcase of a satellite gleamed in the spring sunshine.

—Linda Shiner

Update

Riveter Runs Amok

A riveting machine may have inserted thousands of rivets on the wings of new C-17 military transports with too little or too much force, McDonnell Douglas advised the Air Force last March ("The Joy of Rivets," February/March 1991). Poorly driven rivets can lead to fatigue cracks, but company officials say there was "no significant impact on the product."

The Tour Starts Here

"I get the feeling that I might be doing a little bit to help out aviation by getting people interested."

"It's the personal satisfaction of knowing that you've made someone's vacation, or that you've captured a child's imagination."

"You get a feeling that maybe you're doing something good for a change. You know it's one thing to take care of yourself, but it's another to really do something for someone else. That sounds corny as hell."

Regardless of how they sound, such sentiments are a natural part of the job for the people who give their time to conduct tours at the National Air and Space Museum and the Paul E. Garber Preservation, Restoration and Storage Facility in Maryland.

For over 20 years, the Museum has utilized the services of these volunteers, known as docents. The Museum's corps of 150 docents is a varied lot: men and women, retired and employed, those who work in aerospace professions and those who don't. One trait they have in common is their ability to speak in public, an important qualification for the Museum's direct link with its patrons.

Docents are recruited as they are needed. The Museum gets the word out by advertising on the radio, in newspapers, and at churches and retired-teacher organizations in the Washington area. Candidates are interviewed and the individuals selected begin a six-month training period consisting of lectures by museum curators, required reading, on-the-job training, and what one docent calls "the touchy-feely, psychologically oriented stuff."

Carol James, the Museum's senior docent, has completed 20 years of service. When some of her grown children moved back home, she looked for excuses to get out of the house. James didn't let her lack of an aviation or space background stop her. "I was just like a sponge—I just read everything I could read," she says.

Over the years, James' favorite activity has been giving tours to groups of schoolchildren. She had an inauspicious start: on one of her first tours the students kept quietly slipping away. "They would just keep drifting off and I would try not to notice," she recalls. When the tour concluded at the 1911 biplane *Vin Fiz*, James was down to one boy.

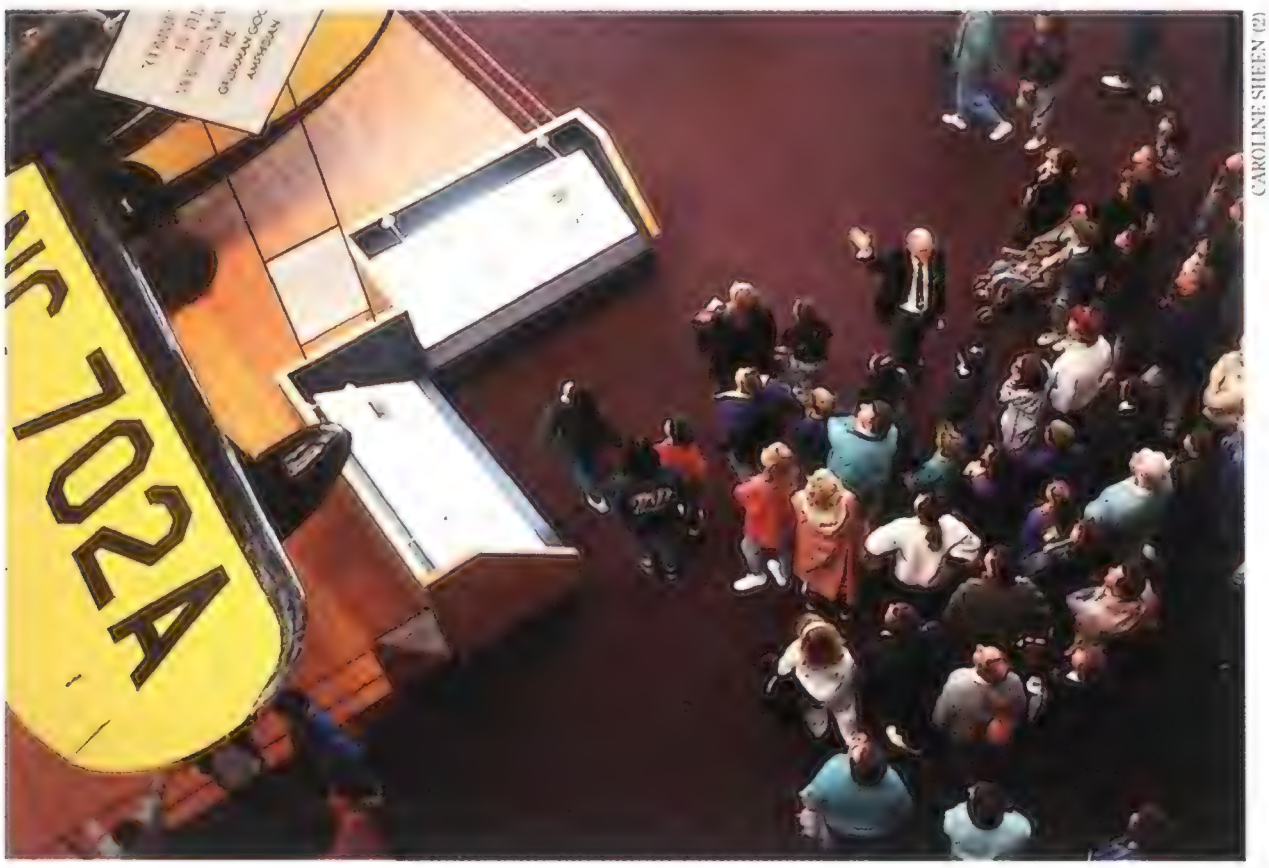
The docents have a fair amount of autonomy in how they give their tours. According to Harry Sher, a retired Air Force officer, "Each docent decides how technical he wants to make his tour.... I don't give as technical a tour as other people give. I hate to say this, but to me giving a tour is in part educational, but it's also show business, and if you don't capture their interest and you don't have them enjoy themselves, they're not gonna listen to anything else you say."

Danelle Simonelli, an information director at the U.S. International Space Year Association, especially enjoys giving tours for blind visitors. "Those types of tours are a lot of fun for me because we get to touch a number of the artifacts that normally you're not allowed to," she says. One group started to examine Amelia Earhart's Lockheed Vega and worked their way around, feeling the aircraft as they went. "I was answering questions for part of the group and turned my back on the rest, and when I turned around they had opened the hatch and were starting to climb into the plane," says Simonelli. The docent politely told them that the cockpit was off-limits.

"One thing one fantasizes about at the Museum is having your favorite celebrity walk up and ask for a tour," says Simonelli, who also edits the *Paper Airplane*, the docents' bimonthly newsletter. A hockey fan with season tickets, she was thrilled when the Washington Capitals hockey team showed up for a visit. Unfortunately, they had just come from a morning practice and were dead tired. "They were some of the slowest walking people I ever took around the Museum," Simonelli says.

Another docent with a full-time job is

The Museum's docents give visitors a mix of education and entertainment.



CAROLINE SHEEN (2)

People who visited the Museum during two days last February may have been perplexed by a new addition in the Milestones of Flight gallery. Suspended in the company of the Wright Flyer, the Spirit of St. Louis, *and the Bell X-1 was...a little red wagon. But it wasn't just any little red wagon. This one could apparently fly, powered by an ordinary household fan and lifted on wings constructed from cardboard boxes. In reality, though, the wagon will take to the air only in the movies. A prop for the upcoming film* Radio Flyer, *directed by Richard Donner* (Superman) *and starring Tom Hanks, the wagon was on display for a fantasy sequence filmed at the Museum.*

Fred Litwin, who owns an antique store in downtown Washington. Litwin's most frustrating tour was for a group of French citizens. The bilingual guide accompanying the group requested that Litwin stand close to him and speak into his ear while he translated into French. "You begin to stumble over yourself," Litwin recalls. "Hearing some noise in French which you can't understand and then back again. It was exhausting and my neck hurt like I couldn't believe."

Ken Robert, who works for the Department of Defense, has been a docent for 15 years. "I've been an airplane nut since day one," he says. "When the opportunity came to be part of [the Museum], they couldn't have kept me away with a big stick." What is it that keeps Robert donating his weekends after all these years? "I get to be a part of the Air and Space Museum," he says. "And I guess I have to admit to being a little bit of a ham too, so I get to be in front of a group and have a little fun. And that's it. It's fun."

—Diane Tedeschi

Refugee Reactor

Washington's best and brightest are currently scratching their heads over the problem of how to get a nuclear reactor back to its home in the Soviet Union. Until someone in Foggy Bottom comes up with a solution, the Topaz II reactor has been granted asylum at the National Air and Space Museum. With the blessing of the Soviets, their reactor is scheduled to go on display—*sans* nuclear fuel—in the Space Hall gallery this June.

The diplomatic limbo began last January, when the 13-foot-tall, five-foot-diameter reactor arrived in the United States for a symposium on space nuclear power (see Soundings, April/May 1991). The reactor was still sitting on a dock in New York when the Strategic Defense Initiative Organization, which had arranged for the loan, learned of an obscure 1954 law that forbids the export of a "nuclear utilization facility" to any nation that is not part of a multilateral agreement on the peaceful uses of atomic energy. The Soviet Union never signed the pact, and although the reactor belongs to them, the McCarthy-era law says they can't get it back.

It's a turn of events teeming with irony: the SDIO, which owes its existence to the Soviet threat, borrows technology from the Soviets, who until recently were the most likely target of the technology, but the Soviets are so strapped that they agree to cooperate anyway—and then a forgotten law left over from another generation's quarrel with the Soviets undermines everything.

Displaying the Soviet reactor at the National Air and Space Museum is an attempt to make the best of a frustrating situation, according to Richard Verga of the SDIO. Verga estimates that the reactor will be at the Museum for three to six months. If necessary, the SDIO will arrange for passage of a private bill to return the reactor to the Soviets. "It's a bureaucratic glitch," says Verga, "and we're fixing it."

—David Savold

Museum Calendar

Except where noted, no tickets or reservations are required. To find out more, call Smithsonian Information at (202) 357-2700 for details.

Extended Summer Hours Beginning Monday, June 17, and continuing through Labor Day, September 2, the National Air and Space Museum will be open from 9:30 a.m. to 7:30 p.m. each day.

New Exhibit Topaz II. A Soviet nuclear reactor designed for use in space, currently on loan from the Kurchatov Institute of Atomic Energy in Moscow. Opens June 3 in Space Hall.

June 1 Monthly Sky Lecture: "The War Comet." Dan Costanzo, amateur astronomer. Einstein Planetarium, 9:30 a.m.

June 5 Exploring Space Lecture: "Galaxies and the Missing Matter." Vera C. Rubin, Carnegie Institution of Washington. Einstein Planetarium, 7:30 p.m.

June 24 Free Concert: "A Celebration of Space." U.S. Air Force Singing Sergeants and the Paul Hill Chorale. Milestones of Flight gallery, 7:30 p.m.

Planning a Smithsonian Visit? The Associates' Planning Packet is yours for the asking. Send a postcard to Associates' Reception Center, Smithsonian Institution, Washington, DC 20560, or call (202) 357-2700. Hearing-impaired visitors can use TDD and call (202) 357-1729. Begin your visit at the Associates' Reception desk, located in the Smithsonian Castle.

To England, the Long Way

I decided to fly from Australia to England because in 1933 it was considered the ultimate test for the men. Amy Johnson had made headlines flying from England to Australia, and I wanted to be the first woman to fly the more difficult reverse route and beat Amy's time in the bargain.

I adored my husband Harry, but I wasn't cut out to be a doting housewife. While he spent his weekends on the golf course I secretly took flying lessons at a nearby airfield. I kept it from him for over a year. I was afraid he'd make things difficult—he'd already stopped me from learning to drive a car, saying it was too dangerous for a woman.

Harry was remarkable. He never tried to stop me even though I know deep down he didn't approve. But when he eventually found out about the flying, he bought me an airplane. Because my husband was wealthy and helped finance me, Australian journalists treated my flights more like social events. They nicknamed me "the airwoman of style" and paid more attention to my appearance than to my performance. I hated that.

Before the flight to England, I did everything possible to ensure I was fully prepared. I learned instrument and night flying, and on the weekends I studied navigation with an old sea captain. I spent months working in the Qantas maintenance hangar at Archerfield so that I could learn to service my Moth, which I named *My Little Ship,* and its Gipsy engine. I can still smell the boiling phenol we used to clean the carbon off the pistons. It turned my stomach inside out.

Poor Harry. He was so worried the morning I left. I told him not to panic if I was reported missing. "Tell them to search along the coastline," I said. "Whenever possible I'll be following the shore, and I'll get down safely."

I was ahead of schedule until I landed in Singapore and overnighted at the Raffles Hotel. To this day, I'm sure I would have beat Amy's record if I hadn't gotten food poisoning. Stupid me—I should never have eaten the fish.

The next day, with the weather perfect

COURTESY LORES BONNEY (2)

Her heyday was in the 1930s, but Lores Bonney is only now receiving plaudits.

right through Malaya, I spent the entire time in bed. When I was fit enough to fly the following afternoon, I took off—straight into the granddaddy of monsoon storms. It was the most unnerving moment of my flying career.

I had been cruising below 1,000 feet to stay clear of some ugly black clouds that had been building for two hours. I was so close to Victoria Point and Ranong, Thailand, that I was sure I'd get through. All of a sudden I was engulfed in torrential rain. It seemed to fall in a solid mass. Visibility dropped to zero. Rain lashed my goggles, and I had to raise them to see my instruments. The Moth's tiny windscreen provided no protection, and the rain stung my eyes and face like driving sand. The airplane bucked and rolled, and a sudden downdraft flung me toward the water. Even with full power I couldn't stop the descent. When I finally broke into the clear I was down to 50 feet.

For the first time in my life I was really scared. It was as though the gods had turned on scores of celestial taps. I was surrounded by jets of rain, some only a few hundred feet across, others miles wide. I had to get down. I said a quick prayer to my "copilot" and turned back toward a small island I'd flown over a few minutes earlier—I'd noticed huts and an open beach. In those days we always kept an eye out for emergency landing areas.

Luckily I arrived over the beach shortly before an approaching storm. The tide had gone out, leaving a strip of hard sand. The only sign of life was a few buffalo grazing on the grassy fringe. I circled once to check the wind, then made a long, straight-in, powered approach. I can still remember how my tires kissed the sand as I touched down. I was often accused of landing like a kangaroo—a series of hops—but this one was a beauty.

The tail hadn't even settled when one of those blessed buffalo lumbered out in front of me. All I could do was jam on full rudder and swerve. The left wheel hit the water's edge, and the airplane slewed into the breakers. The Moth flipped over and my head hit the cockpit coaming.

I came to hanging upside down in my harness with my head underwater. I recall thinking: *What an inglorious end—drowning in the cockpit.* I was struggling to undo the harness pin when the water mercifully dropped away. I was only submerged when each wave came in. I released my harness and plopped head-first into the sea. Finally, I dragged myself up onto the beach.

I was not badly hurt, just a slashed hand and a lump on my forehead. The first thing I noticed was the silence. After the constant roar of the engine, the only sound was the surf and the rumble of thunder. I felt terribly alone. Even the buffalo had disappeared into the trees. As I sat there watching the waves pound my poor little airplane, a teeming rain began. I broke into tears.

It was some time before I noticed a large group of islanders watching me through the trees. They didn't look too friendly, so I felt in my pocket for the revolver Harry had given me. Luckily it had fallen out during the crash, so I had to put on a brave face and walk toward them. They all backed away—I couldn't believe it! I'm less than five feet tall, but they were scared of me.

Bonney's Moth, My Little Ship, *was pristine when it was out of the water.*

Eventually, the islanders helped me drag the airplane ashore. I invented a sort of "heave ho" sailor's chant, and using the power of each incoming wave, we hauled it up onto the beach.

Afterwards, they led me to a large communal thatched hut, and we climbed a ladder to enter it. Once inside, I was overpowered by smoke and the smell of rotting fish. Dozens of villagers squatted on the bamboo floor staring at me. I was quite worried until a young woman led me to a small alcove away from the crowd. She'd noticed my bleeding hand, and now she tenderly cradled it to her face. Her eyes expressed such sympathy that I nicknamed her SOS, for Soul of Sympathy. She became my shadow.

I doused the hand with some whiskey an Australian hotel owner had given me. It was his traditional gift to fliers crossing the shark-infested Timor Sea. "It'll give you a bit of Dutch courage, love," he'd said. I hadn't touched it until then.

The adults tried to entice me to join their betel nut ceremony. They chewed betel the way we take an evening drink. The spitting was more fascinating than the chewing: they'd shoot long streams of crimson fluid through narrow gaps in the cane floor, and they never missed.

The next morning, I removed the shattered wings from *My Little Ship* and got some men to help me roll it right way up. It was repairable; all I needed were good carpenters and the right materials. I drained the petrol tank and used its contents to wash the salt and sand from the engine. I emptied the oil sump and coated the whole engine to prevent corrosion. Finally, I removed the spark plugs and poured some oil into each cylinder. My Qantas training had paid off.

That night I left the little boudoir I had curtained off for myself and sat around the communal fire. I decided to send a message to the mainland, so I got out my flight map and began reading aloud the names of the Malay islands along the coast. When I read out "Bang Biang," several villagers nodded vigorously. So I wrote a note and waved it about and pointed toward the mainland. Nobody seemed willing to go until I bribed one of the men with my gold watch.

To help pass the time, I played Mrs. Robinson Crusoe. After two days I knew the Malay names of every item in the hut and, in return, had taught my Fridays the English equivalent. The children would bring me little gifts of fish or fruit, and I rewarded them with pieces of chocolate from my emergency rations. They liked the silver wrappers best of all.

Late on the fifth day two motor launches arrived carrying the first help my messenger could find: a Scot and a New Zealander employed by the Siamese Tin Mine Syndicate. They thought I was quite mad when I said that I intended to rebuild my airplane and carry on to England. One, patronizing me, advised, "I think you'd better talk to your husband first." Naturally, that sort of nonsense just made me more determined than ever.

On my last evening on Bang Biang I gave SOS some silver coins and showed her how to make a necklace with them. She smiled, but she looked sad. The next morning she was nowhere to be seen. Someone said that she had gone into the jungle rather than have me witness her grief at my parting. We never met again, but I can still picture her clearly.

The tin miners' launches transported me and my airplane to Victoria Point, where I caught a steamer to Rangoon. There my poor little ship got new wings and a tailplane. But the repairs took four weeks, and it was early June before I reached the Middle East.

This part of the flight concerned me most, not because of the torrid heat but because of the problems I'd face if I landed in some out-of-the-way place. I was not sure that my notebook of useful Middle Eastern phrases would help. I knew two by heart: "I always understood your menfolk to be gentlemen" and "Please fetch me a policeman."

Over Iraq I encountered terrible heat, dust storms, and headwinds. One 108-mile leg on the way to Baghdad took three and a half hours. When I landed I was suffering from severe heat exhaustion and unable to complete any formalities. But I will never forget how kind the Iraqis were. I was whisked to a hotel, where the staff applied ice packs to bring my temperature down. I could cry when I read about Baghdad today.

I was arrested in both Turkey and Czechoslovakia after making unscheduled landings due to storms. With no radio and poor ground communications, we faced such problems routinely in those days.

Europe was stormy until I crossed the English Channel. It was a beautiful summer evening, and the countryside looked green and peaceful, its fields and hedgerows so tidy. I remember thinking that missing Amy Johnson's record didn't matter. After Bang Biang it was enough to have reached England. And as the first woman to fly into the prevailing wind, I'd set a record no one could deny me.

As I landed at Croydon Airport in London I was almost rolled over by the slipstream of a big Handley-Page airliner in front of me. I followed its passengers to the terminal. I wasn't expected, and the customs officer never looked up when he asked where I was from.

"Australia," I replied.

His head jerked back and his eyes popped. I got a real sense of satisfaction out of that.

—Lores Bonney
as told to Terry Gwynn-Jones

Four years later, in 1937, Bonney became the first pilot—man or woman— to make the 18,200-mile flight from Australia to South Africa. Only recently, at age 93, was she awarded the Order of Australia.

Face-off

In 1976 the Viking 1 orbiter, flying some 1,100 miles above Mars, photographed a region called Cydonia. Close inspection of one frame revealed what looked like a human face gazing soulfully into eternity. A Viking project scientist showed the image to the press, dismissed it as a trick of light and shadow, and the Face On Mars was forgotten—for a while.

Three years later, Vincent DiPietro and Gregory Molenaar, computer imaging specialists at NASA's Goddard Space Flight Center in Maryland, analyzed a computer enhancement of The Face and decided it merited a serious look. Science raspberried them, but it was too late. A new subculture had been born. Today, two groups—the Mars Project in Santa Cruz, California, and the Mars Mission in Wytheville, Virginia—exist solely to push the idea that The Face and nearby structures may be monuments left by a long-vanished intelligent civilization.

Of the two groups, the latter, founded by science writer Richard Hoagland, is the more energetic. Hoagland wants NASA to reshoot Cydonia when the Mars Observer returns to the planet in 1993, and he pursues this vision with zeal reminiscent of Burt Lancaster in *The Rainmaker*. Like many people involved in missionary work on behalf of fringe topics, Hoagland believes he's being thwarted by higher-ups intent on muffling the truth. In this case, the higher-ups are at NASA. In a 1989 letter to Representative Robert Roe, then chairman of the House Committee on Science, Space, and Technology, Hoagland charged that "*political* obstacles, within...NASA have blocked serious consideration of this evidence for 13 years." The latest alleged outrage involves the cancellation of a documentary called "Hoagland's Mars" that was produced by NASA's Lewis Research Center in Cleveland, Ohio.

Hoagland's version of what happened goes like this: In March 1990 he was invited to speak to a group of Lewis employees. During that visit, Lynn Bondurant, educational programs chief, interviewed him about The Face with a documentary in mind. Hoagland was pleased to learn that Bondurant would "give our work a fair airing, putting it in context of the history of Mars explorations." The program was scheduled for a January 6, 1991 satellite transmission for PBS stations, says Hoagland, when NASA "pulled the plug." Why? Because "the planetary science community hit the roof. They were absolutely furious that this subject was going to be legitimized." Now, Hoagland says, the program is being recut to "put me in the same camp as Percival Lowell—as a well-meaning buffoon."

A source close to the production says the program is being revised "to present other views on The Face." That's probably a good idea, because the script I have doesn't present the full pageantry of Hoagland's ideas. It covers his belief that the arrangement of The Face and surrounding structures reveals encoded mathematical constants, but it fails to mention his wilder extrapolations. Hoagland and geomorphologist Erol Torun argue in a self-published paper that the constants give a startling insight into planetary physics. The theorizing gets pretty dense: "The 'tetrahedral geometry'...is revealing an equivalent higher-order mathematical topology: i.e., a vorticular 'two-torus' energy flow...."

NASA

The bottom line is this: the entities who built Cydonia were trying to tell the universe about a "new physics" that may involve "a hitherto unknown relationship between two of the four basic forces of the Universe—gravity and electromagnetism: i.e., a 'Unified Field.' "

Coincidentally, the miracle math of Cydonia comes into play in a mind-device called the N-Machine, which Hoagland enthusiastically promotes. Invented by physicist Bruce de Palma (brother of Hollywood director Brian), the N-Machine, as Hoagland puts it, "generates more energy out of the interaction between 'space' and the hi-speed rotation of a spinning mass than [is] required by the motors that mechanically rotate those masses." Hoagland dares to say that from which most physicists recoil: "We may be talking about energy coming from nothing." He has been flogging this miracle device on "For The People," an overheated radio talk show in Cedar Key, Florida. Hoagland and Chuck Harder, the show's host, get pretty imaginative. After cancellation of "Hoagland's Mars," Harder said, "I gotta believe one of the reasons...'Hoagland's Mars' has been put on ice has got to be because of the Middle East thing.... Once your program would be transmitted...the press would jump on it, and it might steal some of the thunder from Bush's 'project.' "

Hoagland replied, "Well, it's even more disturbing than that.... 'Hoagland's Mars' is the opening gun to a whole new way of life that taps a virtually inexhaustible energy source for the benefit of mankind. We are about to go to war...over a resource that is really useless."

Hoagland: buffoon or Einstein of the 1990s? Only time will tell. For those wanting a closer look, Hoagland's own version of "Hoagland's Mars"—with all the theories—is available from Curley and Company, Signal Mountain, Tennessee.

—Alex Heard

F-15 Eagle! F-117A Stealth! Tornado GR1! F/A-18 Hornet!

Honoring the victorious Allied pilots and aircraft that mounted the most devastating air assault in history!

FIGHTING JETS OF OPERATION DESERT STORM

F-15 Eagle shown actual size. All other replicas shown smaller than actual size.

Each replica comes with its own display stand.

Authentic scale replicas — precision-crafted in fine American pewter!

Now...own this stirring tribute to American and Allied forces who won lightning-fast air supremacy in the Persian Gulf! Presenting *Fighting Jets of Operation Desert Storm.* This superbly crafted collection is authentically detailed and includes the eight warplanes most instrumental to the stunning allied victory.

Marvel at the low radar profile of the shadowy **F-117A Stealth,** so "invisible" that pilots delivered precision-guided bombs down air shafts! Admire the **F-15 Eagle** — a lone F-15 pilot shot down the first Iraqi planes. The **A-10 Thunderbolt,** also called "The Warthog," reduced tanks to rubble! The **F/A-18 Hornet** — the Navy's newest fighter took out Scud missile launchers.

Handcrafted in fine American pewter.

Each pewter replica is precisely scaled and measures up to a full 5½" in length. The level of detail is awesome, too — fine pewter is famous for that. Each replica is handcrafted in the U.S.A. and comes with an attractive display stand. A fact-filled booklet on the history and capability of each plane is included at no additional charge.

Attractively priced... satisfaction guaranteed.

Available only from the Danbury Mint at $37 each, the *Fighting Jets of Operation Desert Storm* collection also includes the **Tornado GR1, A-6E Intruder, F-16 Fighting Falcon,** and **F-14 Tomcat.** You will receive your replicas at the convenient rate of one per month. Your satisfaction is completely guaranteed. Return your Reservation Application today!

The Danbury Mint

47 Richards Avenue • Norwalk, Conn. 06857

RESERVATION APPLICATION

The Danbury Mint
47 Richards Avenue
Norwalk, Conn. 06857

Please return promptly.

Please accept my reservation for *Fighting Jets of Operation Desert Storm,* consisting of eight authentic pewter replicas, complete with display stands. The cost of each replica is $37.*

I need send no money now. I will receive one replica per month, and will be billed before shipment of each replica. If not satisfied with any replica, I may return it within 30 days for replacement or refund. This subscription may be canceled by either party at any time.

*Plus any applicable sales tax and $2 shipping and handling.

Name _____

Address _____

City _____

State/Zip _____

☐ Check here if you want each replica charged to your: ☐ MasterCard ☐ VISA ☐ Discover ☐ Amer. Express

Credit Card Number _____ Expiration Date _____

Signature _____

All orders subject to acceptance

Allow 8 to 12 weeks after payment for initial shipment.

666EAB1

Jimmie Angel, Devil's Mountain, and the Lost River of Gold

The daredevil bush pilot said he had found a fortune in gold amid the unexplored jungles of Venezuela. All he needed to do was find it again.

by Carl Posey

Illustrations by Anthony Woolridge

My father was an airport engineer, and in 1946 I traveled with him on an assignment to Venezuela. It was there that I heard about an aviator named Jimmie Angel, a name still linked with Venezuela. My father had met and flown a bit with Angel up in Costa Rica, and he still talks about Angel's ability to land "that big cargo Bellanca" anywhere. I have always sensed that this must have been Angel's strong suit—holding an airplane in the gray region before the stall and wriggling it safely to earth in a few hundred feet of reasonably level ground.

In fact, it was a landing that helped make Angel famous: in 1937 he put an airplane down on top of a Venezuelan mountain and had to leave it there. And, oh yes, he was said to have discovered the world's highest waterfall, which was named for him: Salto Angel, or Angel Falls ("Churun Pieru" to the Indians). From the top of Auyán-Tepuí (Devil's Mountain), it falls into a jungle river more than half a mile below.

I never met Jimmie Angel, and the pugnacious, suspicious, middle-aged face that peered from our photo album seemed pretty ordinary, almost the antithesis of a heroic pilot. In those days the truly heroic pilots flew Mustangs and Thunderbolts, Spitfires and Typhoons, so Angel's decrepit Bellanca wasn't enough to excite a 13-year-old boy. But Angel did have a remarkable story that he told my father—and anyone else who would listen. Years before, he said, an old prospector had hired him to fly to a secret site. In a few days' panning, the old man took out a fortune in gold. The prospector planned to make Jimmie a partner, but first he had to return to the States to obtain further financing. There the old man died, taking the secret of the world's richest lode to the grave. Jimmie Angel, my father recalls, always carried a small vial of nuggets as a souvenir—and proof—of the trip. He spent the rest of his life searching for the lost gold.

The three pivotal events of Angel's life have since been told almost as catechism: he met the prospector in Panama about 1930, he discovered the falls in 1935, and in 1937 he landed his Metal Flamingo on the high plateau atop Auyán-Tepuí, where it remained for decades. In a sense, the stranded airplane staked Angel's claim to the mountain, and to the falls. But the other tales are more like the cloud-shrouded

His airplane out of commission, Jimmie Angel was stranded high above the Venezuelan jungle

Although far less graceful than its namesake, the Flamingo did have virtue in its ruggedness.

cliffs of the ancient *tepuís,* appearing and vanishing with the weather, never quite the same from one viewing to the next.

In 1959 a writer for *Cavalier* magazine described Angel's meeting with a prospector named Macready, the flight to Auyán-Tepuí, the gold, and the man's death, all in Crusoesque detail. An equally confident writer in another magazine called the mysterious old prospector "Williamson." Rolan Angel, Jimmie's younger son, who visited Auyán-Tepuí in 1965 and who now has a swimming pool business in California, remembers the prospector as "McCracken."

This is how mining engineer L.R. Dennison, author of the 1942 book *Devil Mountain,* remembers Jimmie's version: "In 1923 I was in Panama with a four-passenger plane on my hands. I was broke, as usual, and wondering just what I was going to do next. While I was sitting in the hotel lobby...an old fellow came up to me and asked if I would fly him to Venezuela. He said that he was a mining engineer and wanted to get to a certain mountain as soon as he could. When he offered to pay me five thousand dollars to make the trip I thought that he was spoofing me, but he showed me his bank-book...and agreed to put the five thousand in the bank for me before we started.... I flew this old fellow to a mountain nine thousand feet high in the Gran Sabana country of Venezuela.... The Indians call it Auyán-Tepuí.

"That mountain is a hell of a place to land a plane. There was a downdraft at one thousand feet per minute, but I landed right where the engineer told me to, by a little stream, and in three days we took seventy-five pounds of gold out of the gravel. We could have taken more, but I was afraid to put too much extra weight in the plane because I had a difficult takeoff. Had to run right to the edge and nose-dive into the canyon which was more than five thousand feet deep. I made it all right, and then flew straight to Panama, where the gold was deposited in the bank and I received my five thousand dollars.... McCracken, the old mining engineer, wanted to make a trip home, to St. Louis, and then return to the mountain for more gold, so he asked me to wait in Panama for him. He was going to take me in with him as a partner, and it sure sounded good to me, but the old man took sick and died. I have been trying to get back to the mountain ever since, but no one will believe what I tell them."

I like my father's version best, for it makes the prospector a bit sneakier and explains why Angel never found his gold. In that version, which must have come from Angel himself after he'd moved to Costa Rica, the prospector taped over the airspeed indicator, altimeter, and compass, steering the pilot with verbal commands. And he didn't just die in the States—he died as his steamer entered New York harbor. Nice touch.

The discovery of the falls also moves in and out of focus. Dennison recalls Angel saying to him, "If you fly into the back country with me...I will show you the highest waterfall in the world. It drops over the edge of a cliff on Mt. Auyán-Tepuí and falls for a mile without interruption." In 1935, Dennison writes, Angel showed him the falls. But word of this sighting did not surface until 1938, when the American press became excited about the mysterious mountain.

Even the Flamingo has its share of ambiguity. For years an aeronautical museum in Maracay displayed an airplane it billed as Jimmie Angel's, even when the original was still stuck in the muck on Auyán-Tepuí. There were, it turns out, almost as many Flamingos down there as there were Jimmie Angels.

According to a Fresno, California newspaper story dated April 17, 1928, one Jimmie Angel took off in a Fokker D-7, flying around South America in a daring journey to Cape Horn. (That Jimmie Angel was said to have served in the Italian army during the first world war, after which he flew for 18 months in China.) The flight seems to have petered out down around Guaymas after mechanical trouble.

Rolan Angel says his father joined the U.S.—not the Italian—army. After coming down with pneumonia and washing out, he joined the Canadian flying corps. He shot down

four balloons and an enemy airplane over France, but when it was discovered that he was too young for combat, he was put to work ferrying airplanes across the English Channel. Unfortunately, Canada's Directorate of History in Ottawa has no record of a James C. Angel in its records of Americans who served with Canadian forces during World War I.

One of the few reliable records was kept by the bush pilot's nemesis: the early incarnations of today's Federal Aviation Administration, created by the Air Commerce Act of 1926 and just beginning to flex its muscles. Today pilots keep their licenses forever and maintain their ratings' currency as needed. In the 1930s, however, you took your tests or lost your ticket. For Jimmie Angel, usually laboring in some jungle outpost when his check rides fell due, life was a nightmare of pleading for extensions. But the official hectoring worked like a snowfall for an invisible man—it gave Angel a discernible track.

Perhaps he really did fly with the Canadians during the war, and perhaps, as an obituary writer said, he did fly in Russia and China afterwards. No official records cover the interval. The first entry in his FAA dossier comes in April 1928, when Angel applied for a transport pilot's license, noting that he had about 3,000 hours in a host of different aircraft and mechanical expertise with a like number of engines. His residence for the past five years, he wrote, had been in the "U.S. with a flying circus, except for 9 months in old Mexico." Under education Angel put: "Learned to fly in Curtiss pusher, soloed March 4, 1915. High school education." About a month earlier, he had passed his check ride in a Fokker D.VII, the same type—perhaps the same airplane—in which he would set out for Cape Horn. The examiner added an odd note: "The written work on this exam was not included with the report due to the fact that the applicant was unable to express himself on paper sufficiently to pass the examination. The examination, therefore, was oral. Applicant is an old-timer and is leaving shortly on flight around South America." The "old-timer" was 28.

There follows another blank in the official record, during which, among other things, Angel reportedly flew a Gotha bomber for Howard Hughes' 1930 movie *Hell's Angels*. There is also evidence of self-promotion. In January 1930 the Department of Commerce's aeronautics branch received a plaintive letter from a Maralyn Cobb of Westminster, California. She wanted the address for Mr. James C. Angel, "a licensed aviator," so that she could "endeavor to reach a settlement for money advanced him for an endurance flight, with security vested in an airplane represented as his property but to which he had not ownership."

Perhaps the endurance flight was the one that newspapers reported as ending badly in December 1930, when, flying a tri-motor Albatross, "Captain Angel" was forced to abandon the attempt after a 95-pound girl stowaway was found in the airplane only 25 minutes into the flight. In Long Beach, California, that same year Angel transformed a biplane belonging to a Mrs. G. Griswald into what he called "a washout." In 1931 he appears in a letter to the aeronautics branch, written from Macuspana, Tabasco, Mexico—one of many efforts to keep his licenses from lapsing.

Up to this point, there is nothing in the files to indicate that Angel had ever been south of Mexico, although a 1928 Associated Press account says that Angel had "served as flight instructor of the Peruvian government." But on September 20, 1932, he wrote to the commerce department proposing a flight of "some months duration" to Venezuela in a Travel Air S-6000B, registration NC0431W. A year later, the *St. Louis Dispatch* trumpeted: "Pilots Seeking Gold Mine." A trail of letters in state department files reveals that Angel did indeed fly the Travel Air to Venezuela.

(Our paths would have crossed briefly. His Travel Air was waiting in Panama for permission to enter Venezuela about the time I was born at the Canal Zone's Gorgas Hospital.)

In October Angel set out for Ciudad Bolivar and points south, a flight of about 1,000 miles over coastal swamp and the rugged northern Andes, with few refueling points and no prospect of repairs—a broken airplane stayed where it fell. Finally he came to the Gran Sabana, a strange territory of dense jungle and open savannahs, where the huge rock formations called *tepuís* soar above the jungle floor like stumps of gigantic petrified trees. The intimidating megaliths are so alien to the human experience that one half-expects to see pterodactyls launching themselves from the sheer cliffs. I think that it was on this 1933 flight that Angel first saw, among the hundreds of dramatic waterfalls spilling from the cracked lips of the *tepuís*, the long tendril of water that now bears his name—and I suspect that it was here that he first conjured up the old prospector who was supposed to inspire funding.

Whatever the outcome of the journey, it did not produce much gold, for the new year found Angel back in the States. But his luck was turning. The American Trust Company wrote Commerce in November looking for a pilot for a "mining venture." And not long after, Angel had his first Wall Street meeting with mining engineer L.R. Dennison. Then

Harry Gibson Dreisbach, who learned to fly in Venezuela, wasn't overawed by Angel's flying abilities.

he was off to California and the pilot's endless quest for an airplane.

According to Dennison's account, the engineer went to Venezuela and built a short strip for Angel at Paviche. Flying a Cessna DC-6B—a four-place, high-wing, 225-horsepower single—Angel arrived there on March 24, 1935, from Ciudad Bolivar. That same day, he flew an entranced Dennison down to Auyán-Tepuí and the giant falls. The two men and Parker Angel, one of Jimmie's brothers, worked together for a couple of months until Jimmie, taxiing the Cessna toward some refueling drums in La Paragua, bent the tips of his propeller. It took until late September for a replacement part to arrive, by which time the Cessna's fabric wings had filled with water. Angel managed to drain the wings and fly the airplane to Maracay, then took a boat for New York, prowling for backers for a serious assault on the alleged mineral wealth of Auyán-Tepuí.

That search lasted until 1937, when Angel headed back south in a Metal Aircraft Corp. G2W Flamingo owned by Joel Eli Meacham. The eight-passenger Flamingo was a big improvement over the Cessna. It grossed some 6,000 pounds and carried 150 gallons of fuel, enough to cross 745 miles of wilderness in one hop. He christened the Flamingo *Rio Caroni,* after a major Orinoco tributary some 30 miles north of his waterfall.

Angel set up camp at the foot of Auyán-Tepuí and its perpetual collar of angry rainclouds and began planning his attack on the mountain. With him was his second wife and perennial partner in adventure, the former Mavis Marie Sanders, a striking redhead everybody called Marie. Also along was a quiet young Venezuelan named Gustavo Heny.

"The Heny family was of German origin, and the older brother, Carlos, was a very successful land developer involved in oil," said Henry Lord Boulton, the tall, patrician president of Aerovias Venezolanos, or AVENSA, the pioneering airline founded more than half a century ago by his uncle. Boulton and I talked in a field of black leather furniture in his 13th floor suite in Caracas.

Boulton has both a sentimental and a fiscal soft spot for Jimmie Angel and his falls. AVENSA operates Canaima, the larger of the two jungle camps located on the Rio Carrao just above its confluence with the Caroní. He wants people to know about the camp, which can be reached only by air, and Angel Falls, as seen from one of the beautifully refurbished AVENSA DC-3s based at Canaima. But Boulton is also fascinated with the mysterious savannahs and their legends.

He opened the interview by showing me an olive-drab duffel containing a few objects—a rifle, a machete, some clothing—that are the last effects of Gustavo Heny. "Gustavo Heny was called 'Cabuya,' " he said, "for 'string,' because he was tall and thin. I had known him from childhood. An outdoorsman, knowledgeable about firearms.... Also very quiet, very low key. Terribly nice. He had a very unsuccessful love life so he tried to stay away from city girls and became a hermit down in the Amazonas district of southern Venezuela. He returned to Caracas to collect his inheritance and died, I think, of civilization."

Boulton wanted Heny to tell him exactly how Angel had come to fly the Flamingo to the top of Auyán-Tepuí. "I interviewed Gustavo to inaugurate our strip in Canaima," he said. "We had asphalted a strip at the camp and I told him we were going to name it Gustavo Heny airport. Heny said that Angel was being financed by a group of California mining people. Mrs. Angel wanted to return to California for Christmas and was putting a lot of pressure on Jimmie to return. It wasn't a trip you took casually in those days, of course. One day Angel told Heny, 'I cannot keep putting off the final assault on the *tepuí.*' Heny said, 'Give me a week so I can get up that mountain, then I can clear off a strip.' Angel put this to Marie, who said no. So Angel told Heny, 'We have to do it now.' Heny said he was crazy, there was nowhere to land. 'I'm staying here,' he said, thinking this would keep Angel from going. Next morning at dawn, Heny woke up to the sound of the Flamingo starting. *God,* he thought, *those people are going to do it.*"

Boulton leaned back in his chair. "Now, at Bocardo and Compania in Ciudad Bolivar, Heny had bought their best sessile rope. He took that rope when he got his gear and leapt into the airplane."

Angel and company landed on top of Auyán-Tepuí. "The top has a lot of springs and brooks, meadows," Boulton said. "He made a perfect landing, cut the magnetos on approach, rolled...then his wheel hit a soft spot, the plane groundlooped, and the propeller hit the ground. That was it."

Angel's own account is more matter-of-fact. In a letter dated December 1937—one of the many letters he sent to what was then the Bureau of Air Commerce—he asked for yet another extension of his license, then added, almost as an afterthought, "I would like to take this opportunity of reporting that I have G2W Flamingo NC9467 stuck in six feet of mud on top of the highest mountain in eastern Venezuela.

Angel told all who would listen about the river of gold and the old prospector who led him to it.

The highest waterfall in the world, Angel Falls plummets over 3,000 feet from the top of Auyán-Tepuí.

This happened October 12th. It was impossible to get ship out with the crew I had with me. It is now necessary to take another airplane back to Venezuela in order to take men and supplies to top of mountain to reclaim the ship. There was no structural damage whatever, although it necessitated a fourteen day walk back to our base camp at foot of mountain. I do not anticipate any real trouble in getting the ship out safely." What is left unsaid, and what Boulton added, is that the Angels would not have survived the descent and the hike back to camp without Gustavo Heny, his jungle savvy, and his stout rope.

But the Flamingo called *Rio Caroni* stayed mired atop Auyán-Tepuí for years. Angel must have flown over his old friend many times when he worked for the Ministerio de Fomento, exploring the Gran Sabana. His airplane then was a Hamilton Metal H-47, number 854E, owned by Angel and one W.J. Barrows. In 1938, partly because of Dennison's reports of this lost world of *tepuís* and an American Museum of Natural History expedition to the area, the U.S. press picked up on the world's highest waterfall, as well as a natural legend: a pilot with the airworthy name of Angel who had stranded his airplane on Devil's Mountain. The combination was a headline writer's dream, and the airplane was still there, verifying it all—the discovery of the falls, the gold, the wartime service, everything.

Evicted from Venezuela around 1942—no one seems to remember why—Angel moved to Costa Rica and became involved with a modestly profitable gold mine there. In 1954 or perhaps early 1955, Jimmie, Marie, and the two red-haired boys, James and Rolan, returned to Santa Barbara, California. Within two years, however, Jimmie was on the road again. While he was returning to South America on yet another search for gold, his airplane—an overloaded Cessna 180, according to an Angel contemporary—nosed over in David, near Panama's Costa Rican border. The next day Angel was diagnosed as having suffered a heart attack, but in the Canal Zone doctors discovered that he had double pneumonia. Later, convalescing at the home of a friend, he suffered a cerebral hemorrhage. He never recovered. On December 8, 1956, in Gorgas Hospital, Jimmie Angel died at the age of 57. His death certificate lists his occupation as "explorer."

Meanwhile, the Flamingo waited on the *tepuí*, as if Trigger were carrying the legend forward after the death of Roy. "In 1942," said a second man who talked to me in Boulton's office, "Carl Mitchell lost a prop on takeoff, so I went on an emergency mission to help him. The oil company he was with also had a Flamingo.... It was just before Angel was expelled from Venezuela. The airplane was locked in the hangar, and they said it was Angel's airplane. But the actual one was still up on the plateau. Finally, around 1974, Major Mier y Teran removed the plane from the plateau.... It was always in danger of being burned by hikers up there."

The speaker was Harry Gibson Dreisbach—at Canaima Camp everyone says it as one word: *capitánharrygibsón*. Through Boulton's narrative, this wily, compact old pilot had watched with his pale, kingfisher eyes, listening to the familiar Angel story unfold. He does not believe the prospector tale or the legendary moment of discovery of Angel Falls. "Angel saw the falls many times," he said later. "One day Cholly Martin, an engineer, took him to see the falls. Angel was a buccaneer—he didn't care anything about waterfalls, he was interested in gold. But Martin told him that discovering the falls would make him famous. So one day Angel went with him. The real discoverer of the falls was Ernesto Sanchez La Cruz, in 1910."

A Scottish-Swedish citizen of Venezuela, Gibson is a pretty heroic aviator in his own right. He was the first pilot hired by AVENSA, and he taught Boulton to fly. "I learned to fly in pterodactyls," he said, grinning. Like most pilots of long and varied experience, Gibson is not much awed by Angel's flying abilities. He said Angel was a good bush pilot, able to land anywhere, but thought to be very poor on instruments—in fact, he rarely had a radio in his airplanes. Gibson recalled that the cabin was always full of gasoline drums and beer. Beer could even be used for navigation: one bottle lasted about a hundred miles.

Gibson knows all about southern Venezuela. He used to fly down to visit Heny in Amazonas, and he is still on the track of Paul Redfern, the American who vanished in 1927 trying to fly nonstop from the United States to Brazil—and who, many believe, crashed somewhere in the Gran Sabana. And Gibson has tracked the Flamingo all over Venezuela.

At some point the airplane was taken to Maracay, Boulton told me, where a replica was made. According to Gibson, the replica's cowling is not rounded like the real Flamingo's, but otherwise it is very close. "The real airplane was put in a public park in Ciudad Bolivar," Boulton explained. "The one in Maracay is the replica." But life in Bolivar was even less kind to the Flamingo than the years on the *tepuí* had been, and the airplane was heavily vandalized. Finally, in 1987, Boulton obtained permission to "steal" the ship. He sent his AVENSA mechanics down to begin dismantling the Flamingo at night. "But the sun came up and people started coming around and saw my people dismantling their airplane," he recalled. "A whole *fomado* came around, ready to lynch my mechanics. The governor intervened. He put the airplane in the hangar, where it was later refurbished somewhat and stored with its wings off, so that we can load her on a Hercules to Canaima Camp. We are going to assemble the Flamingo there."

Boulton grinned at Gibson. "People ask, 'Why not fly it again?' Gibson will land it on the mountain again. My maintenance people can make it flyable. But the minister says no, that every town in Venezuela would want to see it, would want a visit." In Venezuela, the hero of the story is less Jimmie Angel than Jimmie Angel's airplane. Everybody loves Trigger.

Jimmie Angel's ashes were scattered over the falls soon after his death. And his Flamingo—well, his and Joel Eli Meacham's Flamingo—will wind up at the Gustavo Heny airport at Canaima, the jungle paradise that may turn out to be the real Angel gold mine. But Jimmie never had any interest in Canaima; he never stopped there. As Gibson said, he didn't care about waterfalls.

Gustavo Heny was so skinny he was called "String." His jungle experience saved Angel's life.

CAMOUF

Now you see it. Now you don't. And sometimes even when you do, you're wrong.

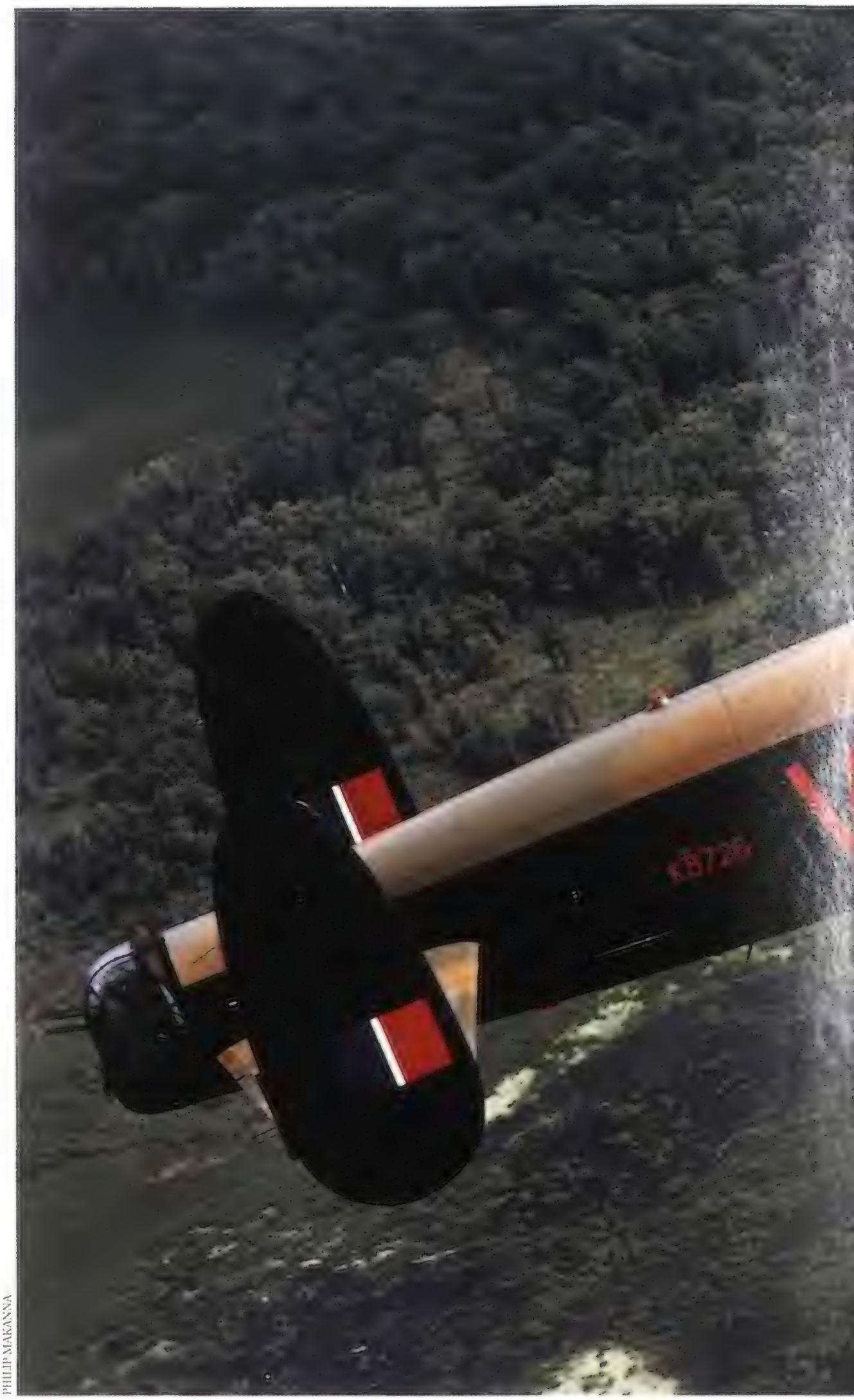
by Edwards Park

It was 1943, and a flight of four of us were searching for Japanese supply barges along the north coast of New Guinea. Streaking over clumps of palms and brushing the still waters of inlets with our propwash, we peered at every darkly shaded patch of shoreline that might hide 40 feet of boat. A small cape jutted into the sea ahead of us, a bare finger of high, flat land thick with yellow-green kunai grass. It held no hiding places, so we skimmed over it to continue up the coast. Then a flash of red caught my eye.

I dipped a wing and saw a red circle, and around the circle a wing of a Zero, then the fuselage and tail. The Japanese fighter, painted in bright splotches of green and yellow—a camouflage for kunai country—had apparently force-landed and had been abandoned. The tall grass had visually swallowed it—except for that bright red rising sun.

We forbore shooting up the obviously deserted, unflyable Zeke and continued about our business. But that fleeting vision remains with me. No episode in my experience more clearly demonstrated the ambivalence of a military paint job.

Back in my war, clever camouflage could prevent the outline of an airplane



PHILIP MAKANNA

The camouflager's conflict: paint helps hide this Avro Lancaster, but its unit markings undermine concealment.

LAGE

from reaching the retina of anyone looking down on it and confuse eyes that peered up at it. Yet the need for identification would almost always intrude just in time to give away the secret. On wings and fuselages, friendly or enemy, drab paint patterns were abruptly splotched with bright stars, cockades, crosses, circles, checkerboards, nose stripes, tail numbers, chevrons, and nose art, all of which shouted for attention: "Hey look! I'm an American, leader of white flight of the Umpty-umpth Fighter Squadron, and my girlfriend is a topless, leggy blonde named Daisy Lou!"

The conflict between the desire to hide and the desire to be seen is as old as warfare. In days of cavalry charges and smooth-bore muskets, organized armies didn't have to conceal themselves. But when the shots came sooner, more accurately, and at longer range, with no smoke to reveal their origin, even the British regretfully abandoned their traditional red coats and eventually turned to khaki.

Just as the devastating machine guns of World War I forced infantry into drab uniforms, so did long-range artillery—accurate, powerful, and targeted by aerial observation—inspire armies to disguise supply dumps, gun emplacements, and other immobile targets with leafy greenish netting. Cleverly done, camouflage nets could turn a motor pool into a patch of forest to the eyes of an aerial observer. The technique continues today.

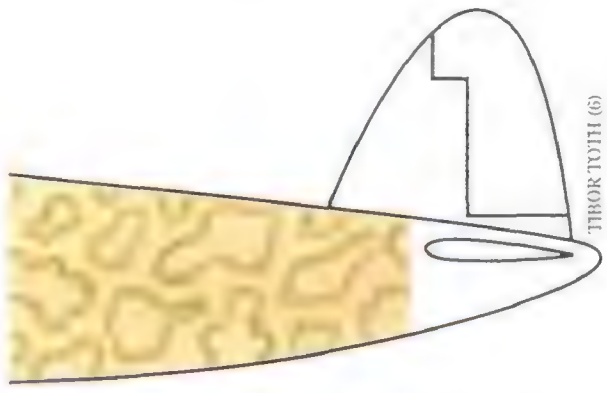
The world's warships began wearing various shades of gray paint around the turn of this century. Then World War I introduced the new threat of submarines, and navies sought a camouflage that would confuse the eye at the periscope. In Britain, help came from a zoologist: John Graham Kerr had visited the jungles of South America and never forgot the way a live creature, spotted and streaked by nature, would remain invisible until at the last moment it exploded into motion. He suggested that nature's streaks, replicated in paint, would tend to disguise the size, direction, and speed of ships.

Though the British admiralty didn't adopt Kerr's specific suggestions, the general idea took root. Troop ships in convoys were daubed in strange zebra stripes, zigzags, and Picasso-like cubic forms of contrasting light and dark. It never bothered the U-boats much, but it probably made the ships' passengers feel safer.

BRIAN D. NICKLAS

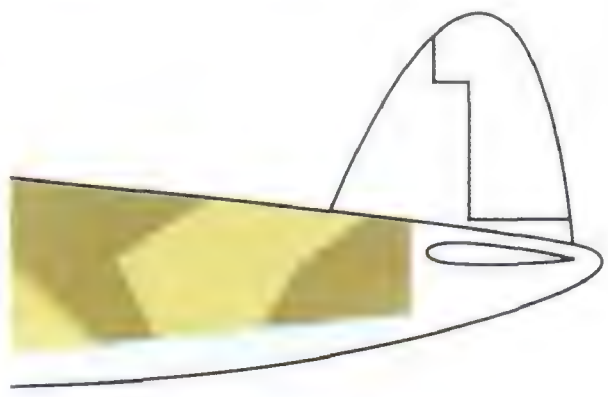
Flip side: this AT-6 trainer got high-visibility colors so searchers could find the inevitable accidents.

Kerr's ideas were even tried on World War I aircraft. The Germans used stripes and zigzags, which only rendered their airplanes more noticeable than ever. A noisy biplane trundling a couple of thousand feet overhead at maybe 100 mph was hard to hide. Infantry sitting in the mud generally shot at anything that flew, and all airplanes looked the same to the ground troops. So identification took precedence over camouflage in World War I. Wings and fuselages sported Maltese crosses and red-white-and-blue cockades that flashed like circus posters.



TIBOR TOTH (6)

Reggia Aeronautica (Italy), desert, 1940s



Luftwaffe (Germany), early 1940s

Yet some camouflage proved moderately successful. On both sides, night bombers and zeppelins went into mourning. The big German Gothas and British Handley Pages wore a matte black, dark blue, or maroon finish that wouldn't gleam when a searchlight found it.

In daylight, a coat of camouflage on an airplane's upper surfaces helped it to blend in with ground patterns. The Germans tried dark blotches of green and brown, then settled on small spots, usually lozenge-shaped, of yellow, pink, purple, green, and blue. This was an adaptation of late 19th century pointillism, an artist's method of using many spots of color to form a sort of visual stew that the viewer sees as a single color. Used as camouflage, the technique gave a German Albatros, for example, the spotted look that nature so often provides as protection. Devilishly hard to see, reported the young American pilots of the Lafayette Escadrille when they first went into action. John

Graham Kerr would have been delighted.

But those hard-edged, jet-black crosses on wings and fuselages gave everything away. Clearly, mixing camouflage and identification wouldn't work then, didn't work on that Zero I flew over, and doesn't work today.

World War I had turned airplanes into weapons, and ideas for camouflaging them got much more attention in the peace that followed. Paint them in dark, drab colors above and light underneath, ordained the brass. They got that idea from a famous American artist named Abbott H. Thayer.

Thayer's now remembered as a late 19th century romantic who painted women and children as gentle virgins and seraphim. But he started his career painting animals, and after retiring to New Hampshire, he and his son wrote a book entitled *Concealing Coloration in the Animal Kingdom.* In it he expounded a rule of thumb: the part of an animal that receives the most light—the upper surface—is darkly colored; the part that is unlit—the underside—is light-toned. Some naturalists, notably Theodore Roosevelt, disagreed with Thayer's rule, but "counter shading" has been the technique of choice for painting warplanes from about 1918 to the present.

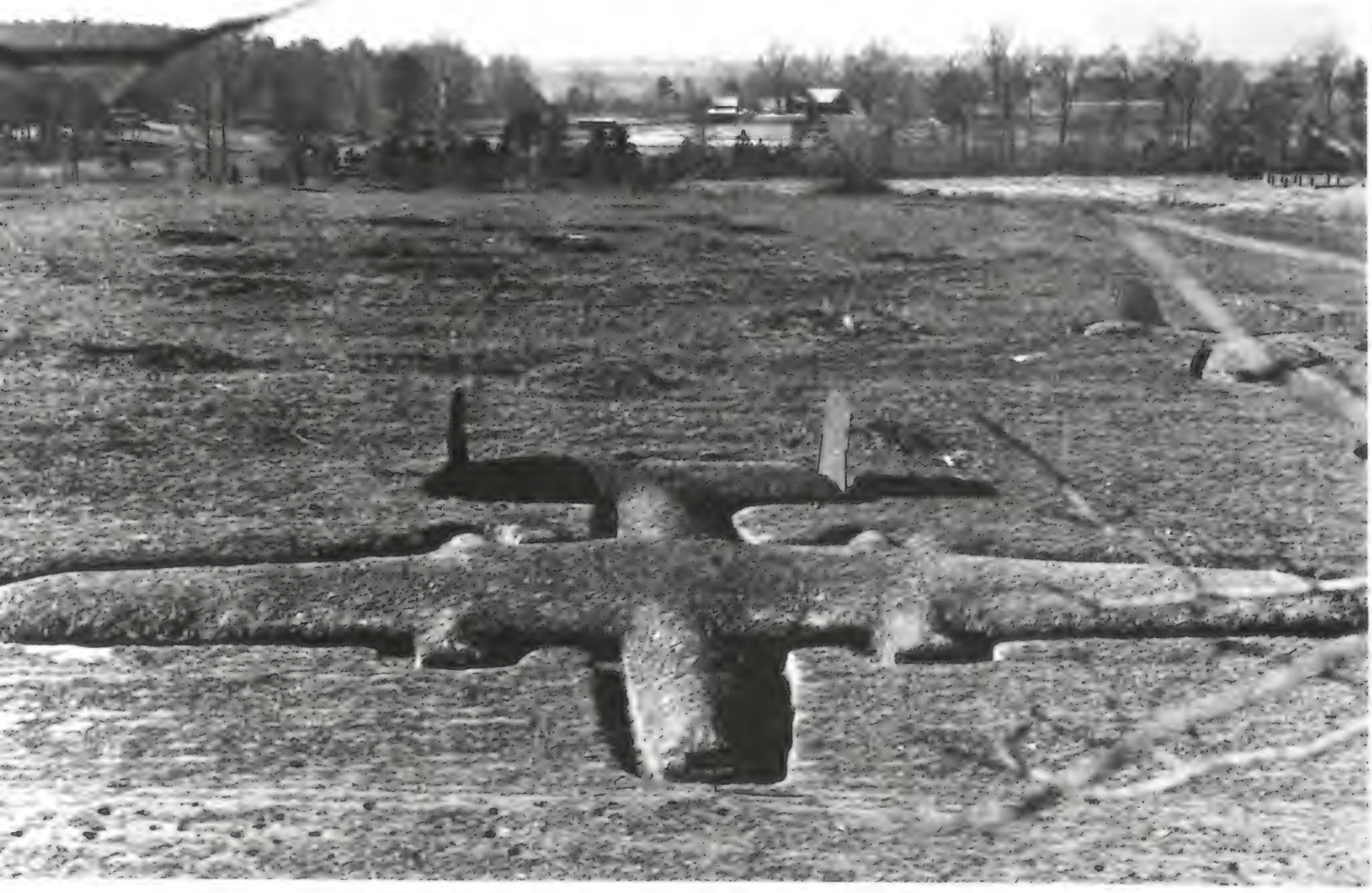
Dana Bell, the National Air and Space Museum's resident expert on the coloring of aircraft, points out that as one side gains air supremacy, the need for camouflage dwindles. In World War I, the members of Manfred von Richthofen's Flying Circus deliberately showed themselves off with bright paint jobs; von Richthofen's own airplane was red. The coloration was a signal that wherever they flew, they owned the air. Hermann Göring, who took over von Richthofen's group after the Red Baron was killed, flew an all-white Fokker D-VII.

The Allies generally avoided showing off, even though they pretty well controlled the air by the end of the Great War. Nose sections were often painted in squadron or group colors. Naval airplanes usually took to battleship gray or sometimes blue; brown-green camouflage was a good way to be seen quickly over water.

Between the wars, during the Golden Age of Flight, the military used a dark olive drab or battleship gray above and pale blue or off-white below. My World War II P-39 Airacobra was a dirty dark green above and dirty blue-gray underneath. And even today's fighters, Navy as well as Air Force, are a combination of generally dark grays above and light grays below. Thayer's rule still rules.

The tendency of World War I student pilots to crack up resulted in the U.S. Army's ubiquitous yellow. Splashed on the top of the upper wing, it made a downed trainer easy to spot from the

Decoy fakery: a B-25, outlined in trenchworks, had a pair of phony fins to complete the deception.



NASM

Emulating enemies: F-5Es from a U.S. Air Force "aggressor squadron" train in Warsaw Pact colors (left).

Rule of thumb: if its paint matches the earth it flies low-level missions, as this F-111 does.

RANDY JOLLY

air. After the first world war, yellow eventually became the standard wing and tail color for all Army airplanes. Rudders blazed with a bright blue vertical band meeting red and white horizontal stripes. The wartime cockades had long given way to red-centered stars in blue circles.

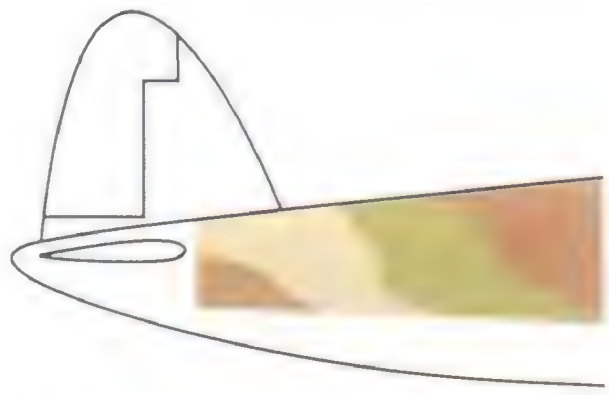
Those spots of brilliance, and the yellow upper wings, opened the doors to an era of spectacular color as the old truism asserted itself: if you don't need camouflage, forget it. Unit patches suddenly adorned the olive drab fuselages; bright diagonal stripes slashed across them; engine cowlings gleamed with primary colors to identify squadrons. These were the military's nickel-and-dime days, and in its hunger for appropriations, the Air Corps craved the limelight.

In the 1920s the Army trainers got a nice medium-light blue on their fuselages. The old Stearmans, Fairchilds, Vultees, and other primary and basic trainers that taught my generation were a handsome group of teachers, lined up yellow wing to yellow wing, blue fuselages all in a row. Navy primary trainers adopted a bright yellow for the entire airplane—hence the sobriquet "Yellow Peril."

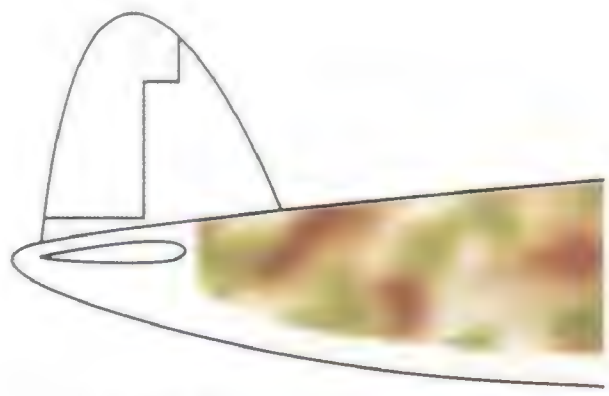
When the seemingly endless stocks of olive drab paint at last started to run out, Army blue remained in good supply. So the Air Corps, like Picasso, went through a blue period. Camouflage? Who needed it? Even combat airplanes were brightly uniformed in blue and yellow. Add those same dazzling national and unit insignia, and they seemed costumed for a Hollywood spectacular. They were a happy sight in Depression years: an immaculate echelon of P-26s, streaked with ribbons and chevrons, proudly decorated with badges, humming over the local fairground.

War rumbles in Europe finally ended the brilliance of peacetime paint and reminded the brass about camouflage. They began experimenting with temporary watercolor paint, which allowed aircraft to do a quick change. Photographs taken from above during maneuvers in the late 1930s show many airplanes blending magically into the pattern of field, forest, hedge, and roadway below.

Water-soluble paint could be washed off by a wet cloth—also by a heavy rain. Was it worth the time and effort of daubing it on and maintaining it? The Air Corps commander thought not. In the spring of 1939, General "Hap" Arnold ordered that camouflage paint be made permanent. After some demurring, that summer the Army trotted out various camouflage schemes at—of all places—the National Air Races at Cleveland.



U.S. Air Force B-1A, early 1980s



Armée de l'Air (France), early 1940s

It was quite a day. Roscoe Turner, sporting his waxed moustache and wearing a natty, self-designed uniform, won the Thompson Trophy for the third time, and the Army Air Corps displayed the 27th Pursuit Squadron in war paint: brand-new Curtiss P-36s lined up on the tarmac and flew over in echelon, each fighter sporting a different paint job. They ranged from dazzle stripes to plain colors, from patches of white, sand-orange, and yellow to red, purple, brown, and green.

Some of the combinations worked remarkably well, that day at least. But when the brass made their choice of a permanent paint uniform for Army airplanes, it went right back to olive drab on all upper surfaces, this time with undersides counter shaded, according to Thayer's rule, in pale "neutral gray." And that was the way Army fighters and bombers of 1940 and '41 emerged from factories newly gearing up for wartime production. Stars, rudder stripes, and unit insignias (often as decals) were added later. As serious business drew

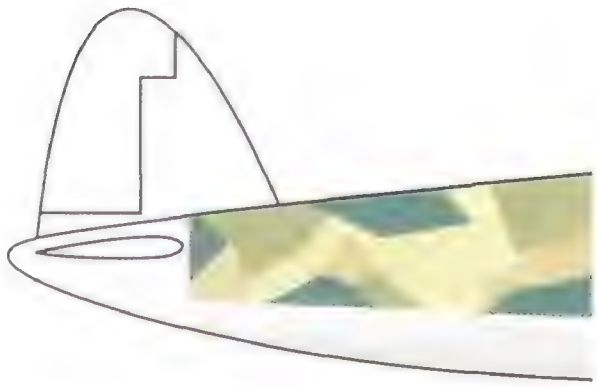
nearer, star markings on wings were reduced to one on top and one underneath. Two more were allowed on the fuselage. Most units now did away with chevrons and patches.

Pearl Harbor produced another change which has lasted to this day: the traditional red circle that had always filled the inside of the white star suddenly made every hot-blooded American fighter pilot think he was seeing a Japanese rising sun. Bullets flew with abandon. One side or the other had to change, and since Japan was winning, we were elected. On every U.S. air base, ground crews went to work with spray paint, whitening out our red circles. When I went overseas in 1942, I could often still make out the pale pink ghost of a circle within the star.

Even before those scary early days, General Claire Chennault's Flying Tigers had adopted their famous sharks' teeth over their camouflage. It was good for morale. Our P-39s kept our squadron color—buff—on spinners and propeller tips. Our olive drab wore thin, our neutral gray got dirty. We had several P-400s, the Airacobra's export version, painted in Royal Air Force colors: dark green and brown. It wore out too. Paint wore off the leading edges of the wings, exposing aluminum. And as our strength increased in New Guinea, we cared less.

Changing fortunes of war in Europe altered the look of Allied fighters and bombers over there. They forsook drab humility and went silver, with invasion stripes of black and white to warn off our own gunners. In the Pacific, as the tide turned, my squadron got unpainted P-47s and loved the bare aluminum sheen of victory. We swore it increased our airspeed (it probably did add a couple of miles an hour). Now our tail sections were white for quick identification, our squadron markings and gaudy nose art bigger and brighter. Our modest buff squadron color suddenly became golden yellow—partly, I suspect, because none of the new painters knew exactly what buff was. Anyhow, yellow was prettier, and hey, we were winning!

As we eschewed camouflage, the Japanese embraced it. The bright silver bomber fleets that we used to hide from, the Zeros with gleaming black or red cowlings that we used to meet, became drab and dark, or blotched with

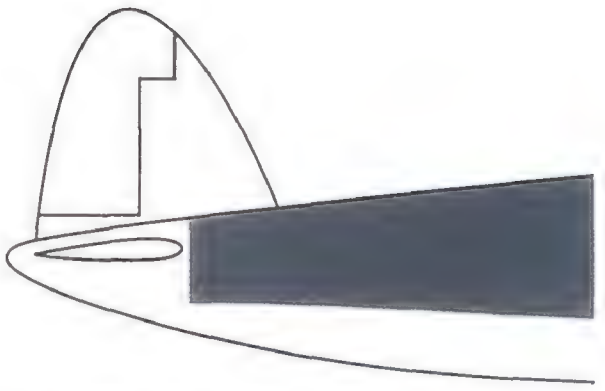


Svenska Flygvapnet (Sweden), current

the ground colors of their bases—green and yellow, like our discovery in the kunai, dark green for jungle, even pink and yellow where the home base was a coral strand. And those red circles seemed to darken with imperial hopes.

Interestingly, Japanese airplanes retained their polished, waxed look. Seen in the distance, they were always unmistakable—dainty, slender, sparkling

shapes, changing direction with a single flick, like a school of fish. Camouflage seemed to mean little when you reached a level of experience where you *felt* enemy airplanes the moment you saw those distant spots. Someone once asked the great Billy Bishop of Canada how he identified German airplanes in World War I. "You learn to sense their presence," he said.



Luftwaffe, late 1980s

RANDY JOLLY

Did camouflage paint ever do any good? In a few cases, yes. Navy airplanes entered World War II in battleship gray and changed to darker blue topsides shading to fish-belly white below. When they flew low over the Pacific, they were very hard to see from above. Experiments showed that airplanes attacking submarines at low altitude were nearly invisible if they were gray above and white below. But any Army or Navy airplane could be assigned to sub patrol, and considering that a double paint job added a lot of weight, only the under surfaces were repainted white.

White was also daubed on aircraft serving in Alaska. An invention called haze paint, which reflected only blues and violets, was tried on high-altitude F-4s and F-5s—reconnaissance versions of P-38s also known as "photo Joes." Under the right conditions, they were almost invisible. That matte black from World War I covered the P-61 "Black Widow" night fighter and also bombers used exclusively for night attack. I remember a squadron of night-bombing PBY Catalinas in New Guinea called, naturally, the Black Cats.

But the camouflage of deceit never got far with airplanes. In silhouette they're too easy to spot, and even at high altitude they are apt to be revealed by contrails. Yet sneaky German schemers proposed such asymmetrical designs as a single-engine fighter with wings of uneven length. The engine was to be mounted on the long side. The idea, apparently, was to drive enemy pilots onto the path of permanent sobriety. A search for similar confusion later led an artist to try painting the outline of a cockpit canopy on the underside of a jet fighter.

The best deception is the erasing of insignia. I remember a day when some of us were watching C-47 transports land in the Ramu Valley of New Guinea after a troop-carrying mission. One after another turned from base leg onto final, veterans all, their olive drab uniformly grimy and oil-stained, their white stars barely visible.

Fighter fade: it's the F-16's performance, not its "gray on gray" paint, that makes it elusive.

"That squadron's got an extra," someone said. "I count 13."

And just then the last in the line peeled away from the strip and rumbled off to the north toward its Japanese base. I suppose the airplane—minus its "meatballs"—had been taking photographs. I've often wondered if I'm in a forgotten file somewhere in Tokyo, a tiny figure in sawed-off shorts, looking up in astonishment.

In 1950, the powerful new U.S. Air Force went into the Korean War with a blaze of unit markings on its new jets and little thought of camouflage. Having cracked the sound barrier, military fliers were enraptured with Mach 1, and F-86s and Navy F-9F Panthers took on North Korean MiG-15s at blistering speed, clad in unpainted aluminum and the Navy's blue, or often white—it simply didn't matter.

But Vietnam was another story: missiles and sophisticated radar kept fighters down on the deck. Speed gave way to maneuverability as the big F-4 Phantoms and F-105 Thunderchiefs twisted away from enemy surface-to-air missiles and air-to-airs. Camouflage came back into style—dark green, light green, and tan in a standard pattern. Identification was mostly electronic, and decal markers drew heat-seeking missiles, so bright white stars began to shrink, then fade to a mere outline in black or gray. Now you can barely see the old star, so modestly is it displayed.

The blotchy, three-color patterns of drab paint that got their start back in the Great War are still seen on airplanes that fly low-level missions. Sand colors helped conceal low-altitude aircraft in the Persian Gulf. Matte black covers many bombers. But camouflage on the newest of the new fighters is as sophisticated as they are. Only radar can spot them, and their camouflage is designed to fool its invisible searchlight of microwaves with something called stealth.

Luckily for us, the Air Force's Thunderbirds and the Navy's Blue Angels exhibition teams still wear their spiffy, bright uniforms for airshow performances, and it's hard to imagine them barrel-rolling in the different shades of gray—what Dana Bell calls gray on gray—of operational fighter squadrons. It's only on Armed Forces Day that you may get to see an ordinary fighter from a line unit do its stuff. I remember an F-16 rolling to the end of the runway at Andrews Air Force Base, slender and eager on its stilt wheels. It howled off the ground, then put its nose straight up and rocketed vertically out of sight. I could only hear a rumble way off on the edge of space.

When it appeared again, it came out of nowhere, cracked over the field like the snap of a whip, jammed itself around in a 9-G turn with creaming contrails coming off its wings, swept back on the deck, inverted, pulled around again, suddenly slowed to a breathtaking near stall, nose high, then thundered back up, dropped gear and flaps, slid down to the strip, greased on, and taxied demurely to the flight line as though nothing had happened.

What color was it? Gee, sort of gray, I think. I never really saw. ✈

Star of Desert Storm: the F-117 proved in the Gulf war that the ultimate camouflage—stealth—really works.

It's been hailed as the most important book on air power in 10 years.

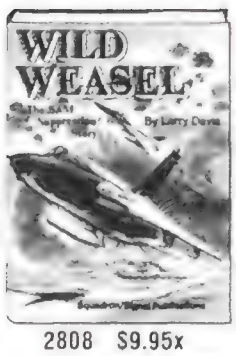
It's yours FREE

when you join us now!

From Spitfire to Stealth, leave it to *The Military Book Club* to bring you the widest—and best—selection of military reading. Make it a point to join us. Today!

6296 $18.95

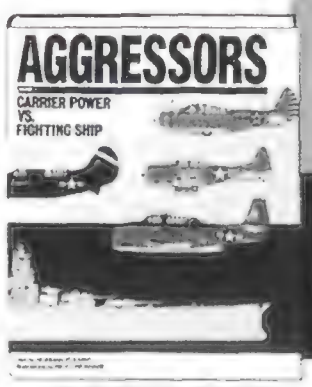
FREE plus 3 more for 98¢ with membership



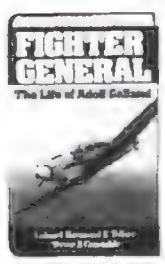
2808 $9.95x

5926-9999* $24.95

0307-9999* $39.95



5108-9999* $24.95



6239 $27.50

6007++ $19.95

6049 $19.95

1339-9999* $24.95

0174 $22.95

5645 $22.50

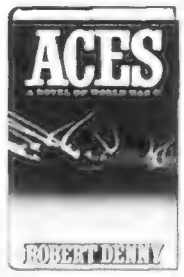
9506 $19.95

6270-9999* $49.95

5983-9999* $25.95

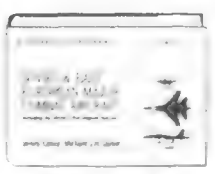
9514 $27.95

5553 $24.95



5678++ $18.95

6221 $22.95



0281 $15.95

5611 $19.95

6122 $19.95

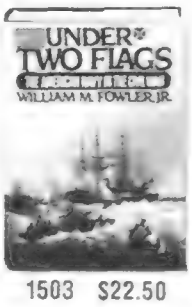
4820 $19.95

1396 $24.95

1404+ $14.95

5652+ $17.50

0760 $21.95



1503 $22.50

1099 $24.95

0984 $24.95

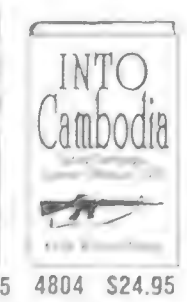
0752-9999* $25.95

1081 $17.95

0034 $19.95

0703 $18.95

0687-9999* $29.95



4804 $24.95

HERE'S WHAT YOU GET WHEN YOUR MEMBERSHIP IS ACCEPTED . . .

A GUARANTEE OF SATISFACTION. If you're not 100% satisfied with the 3 books you've chosen, return them within 10 days *at our expense* and owe nothing. *The Air Campaign* is yours free to keep.

THE FREE CLUB MAGAZINE. You'll receive up to 15 issues a year. Each issue reviews the Featured Book Selection(s) plus a wide variety of alternate books from the Club's extensive library.

SHOPPING MADE SIMPLE. To get the Featured Book Selection(s), *do nothing*—it will be sent automatically. If you prefer another book—or none at all—simply return your Member Reply Form by the specified date. A shipping and handling charge is added to each order.

HUGE DISCOUNTS ON HARDCOVER BOOKS. Save as much as 30% off publishers' edition prices. Club books are sometimes altered in size to fit special presses.

AN EASY-TO-MEET OBLIGATION. Take up to 2 years to buy 4 more books at regular low Club prices. Afterwards, you may resign membership anytime.

RISK-FREE RETURN PRIVILEGES. If you get an unwanted book because your Club magazine was delayed and you had less than 10 days to respond, simply return the book *at our expense*.

PRICES SHOWN ARE FOR PUBLISHERS' HARDCOVER EDITIONS. CLUB HARDCOVER EDITIONS SAVE YOU UP TO 30%.

THE MILITARY BOOK CLUB ★★

Your #1 Source for Military Books

MAIL TO
The Military Book Club
6550 East 30th Street
P.O. Box 6351
Indianapolis, IN 46206-6351

Please write book number(s) here if you accept The Air Campaign. You may choose a different FREE book. Simply circle out the book #6296 and write in the number of the book you prefer.

FREE BOOK #6296

YES! Please enroll me in *The Military Book Club* according to the risk-free membership plan described in this ad. Send me *The Air Campaign*, FREE, plus the 3 BOOKS I've indicated. Bill me just 98¢, plus shipping and handling.

Mr. Mrs.
Miss Ms. _____
please print

Address _____ Apt _____

City _____ State _____ Zip _____

Members accepted in U.S.A. and Canada only. Canadian members serviced from Canada, where offer is slightly different. Sales tax added where applicable. We reserve the right to reject any application.

ASP 7/91

27019 04

If you select a book that counts as 2 choices, write the first 4 digits of the book number in one box and 9999 in the next


CMU
NASA
JPL
MARS

Getting Around on Mars

The Red Planet's first robot rover will need to roll, walk, hop, jump, lunge, slide, or glide.

by William Triplett

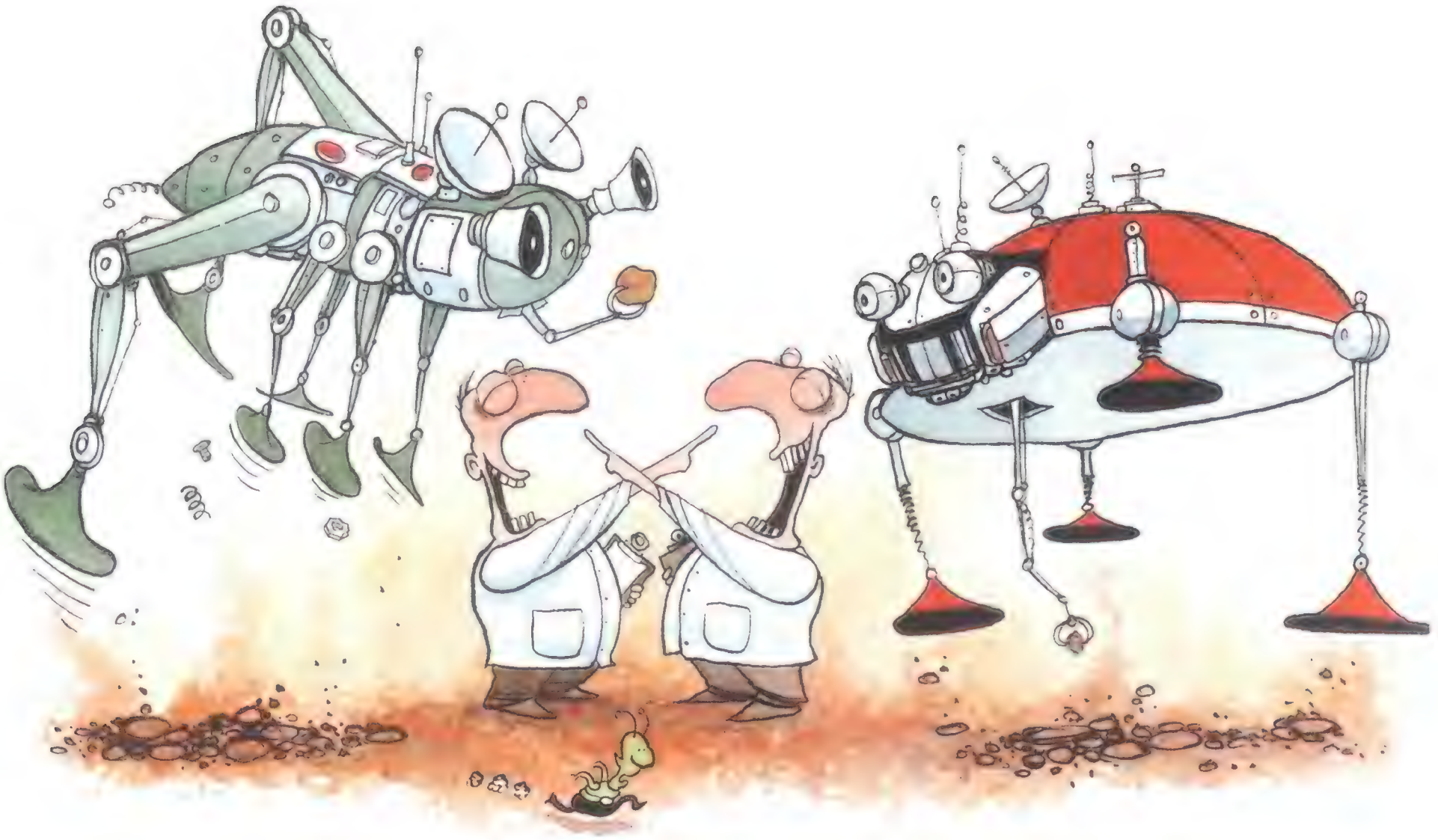
Illustrations by David Clark

Wheels or legs? Roll or walk? What's the best way to ramble across Mars? When it comes to building an unmanned rover that can cross the terrain of an unexplored world, that is the question. And one that NASA will have to answer in its quest for the ultimate off-road vehicle.

The biggest challenge for any rover will be the rugged Martian environment. Imagine mountains and volcanoes three times the size of Mount Everest, gorges ten times as big as the Grand Canyon, and terrain either pocked with dust bogs or studded with mammoth boulders. It's clearly a world that requires a vehicle with great flexibility and mobility.

There is also the planet's thin, hostile atmosphere to consider. Temperatures range from a frigid 0 to a brutal –200 degrees Fahrenheit, cold enough to shatter a steel frame. Drop a conventional vehicle, like an Oldsmobile, on Mars during one of its dust storms and the gears and joints would foul up in no time. In addition, the extreme cold would harden and crack the car's rubber tires and freeze the lubricants and liquids.

With such extreme planetary conditions to overcome, NASA wants to be sure it gets the right vehicle. Problem is, nobody really knows what the right vehicle is. But the agency hopes that comparing two rover prototypes now under development, one at the Jet Propulsion Laboratory in Pasadena, California, and one at Carnegie Mellon University in Pittsburgh, Pennsylvania, will mean the difference between buying a dependable rover and getting stuck with a real planetary lemon.



"The idea of an unmanned rover goes back to pre-Apollo days, when the old Surveyor [lunar rover] missions were being designed," says David Lavery, manager of NASA's planetary rover program. "There's been an ongoing interest for almost 30 years." The interest didn't become specific, however, until 1986, the year of the *Challenger* accident, when NASA commissioned studies to determine how to get itself back into space. An unmanned geological mission to Mars, dubbed the Mars Rover Sample Return mission, was one of several recommendations.

"The vehicle would be landed on Mars," explains Lavery, "and it would do a series of traverses to different locations to collect soil and rocks, perform analyses on them, then deposit the samples in a lander. The lander would eventually lift off and return them to Earth." The sampling might take up to a year to complete, with the overall mission, from initial launch to lander return, perhaps requiring four years.

In December 1988, NASA inaugurated the Pathfinder program, which looked at technologies necessary for a Mars sampling mission. Given a communication delay running upward of 45 minutes for the round trip between Earth and Mars, tele-operation or remote control wasn't practical. Any rover would need some sort of onboard intelligence, or semi-autonomous navigation system, to enable the machine to think and see for itself.

Clearly, NASA needed a mix of robotic brains and brawn such as no one had ever seen before. (The Surveyor lunar rover, never launched, was essentially designed for tele-operation; the Apollo lunar rovers were manned machines.) "Robotic mobility concepts and navigation systems have been around, but nothing to this extent," says Melvin Montemerlo, manager of automation and robotics at NASA. "No one has ever really integrated mobility studies with navigation studies with the specific purpose of this kind of space mission in mind."

Though funding for rover technology has been somewhat meager, NASA proceeded with its search by rounding up the usual suspects in rover R&D. "We went first to JPL because they'd been part of the Surveyor program," says Lavery, "and they've had a continuing interest in planetary rovers ever since. So it was logical for NASA to go back to them and say, 'Why don't you guys pick up where you left off?' "

NASA then noticed Carnegie Mellon University. CMU's Robotics Institute had built three robot "janitors" for cleaning up part of the radioactive spill at Three Mile Island. Not only had the robots been built on schedule and within budget, they had also worked—not always the case in federal procurement. "We figured that qualified them as someone to talk to," Lavery says.

The two design teams went to work. JPL began by commissioning Martin Marietta's astronautics group to come up with some new mobility concepts for a semi-autonomous rover that could cover two-thirds of a mile a day, cross a three-foot chasm, go over a three-foot obstacle, and drill to a depth of nine feet.

"When we brainstormed we just threw open the doors," says R. Stephen Price, principal investigator for planetary rover technologies at Martin Marietta. "We looked at everything and we knew right away there were basically two ways to go—big and dumb or small and smart." A smaller vehicle would require more sophistication to handle obstacles. In other words, twigs aren't a problem for an elephant, but an ant must go around them. Martin Marietta also came up with concepts that laid down track in front of the vehicle and then picked it up behind, like a train with its own rolling loop of railroad. "We had a concept of

two tripods on the ends of a beam," says Price "and a sliding weight that 'walked' the thing by counterbalancing weight."

Other concepts included a menagerie of hoppers and jumpers, which resembled everything from robotic dogs to jet-propelled pogo sticks. But the hoppers and jumpers tended to be small and therefore limited in their ability to carry scientific equipment.

Then there was the concept of the "Mars ball," which looks something like a soccer ball with a thyroid condition. It would roll by sequentially deflating some segments while inflating others. Rounding out the field of contestants was a self-rolling wheel that packed the scientific equipment into its axle, as well as a vehicle developed at Ohio State University that resembles a giant robotic grasshopper.

Despite the multitude of possibilities, JPL went back to the old Surveyor rover. For one thing, wheeled concepts had been proven in space with the Apollo manned rover. And Brian Wilcox, supervisor of JPL's robotic vehicles group, had experience with wheeled rovers dating back to his childhood. His father was director of research and engineering at General Motors, the company that designed Surveyor. As a 12-year-old, Wilcox was allowed to drive a six-foot Surveyor model at a GM company picnic. ("There's a lot of incest where rover history is concerned," says Donald Bickler, supervisor of technology and advanced systems at JPL.) The new progeny, an expansion of the Surveyor concept, was christened Robby.

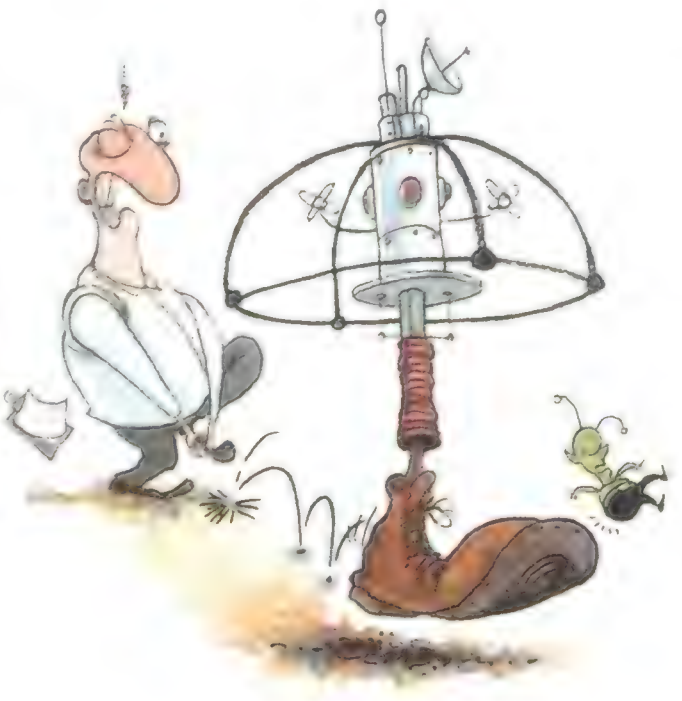
The first problem Robby's designers tackled was the creature's navigation system. They started out with a combination of video cameras and computers and spent the next two years developing the software. Robby (looking very much like Surveyor's big brother) uses its cameras to survey the surrounding topography, then correlates the data with a programmed topographical map of the region in order to locate its position. To get to any desired point on the map, the computers tell the power source to get the machine rolling, while plotting the path of least resistance by steering Robby away from insurmountable obstacles.

"It's just like if you were trying to get from L.A. airport to Pasadena by car," says Roger Bedard, manager of rover technologies at JPL. "You'd have your big map laid out and you'd find where you are on the map and then pick out your freeways. Then, using your eyes like Robby uses its cameras, you'd look around for signs that get you onto the freeway, and you'd be trying to avoid any potholes or big branches that might be on the road."

For now, Robby doesn't move so much as he creeps. During a test conducted a year ago, Robby had to navigate a small stretch of the dry river bed adjacent to the JPL campus. Supervising the test were several of Robby's creators, decked out in JPL's couture of sport shirts and slacks. As at JPL in general, the atmosphere of the test was definitely informal. Even Robby seemed to be hanging loose.

His assignment was to travel some 50 feet to a designated spot. Trouble consisted of a sizable mound of soil. Robby would have to plot and execute his own course with no help, a task he had yet to accomplish. In final preparation the designers checked Robby's various parts, expressing their last-minute concerns with the kind of parental anticipation you see in a father about to watch his kid wobble off on a two-wheeler for the first time.

As he began millimetering along, Robby looked almost human. He timidly surveyed the mound, looking as if he were trying to feel his way around. He rolled on some easy ground first, then headed for a rock about the size of a shoe. But the trusty little rover labored over all obstacles with a steady, gingerly persistent effort.



Given Robby's quarter-mile-an-hour top speed (bringing new meaning to the words "slow motion"), watching him operate is about as fascinating as watching home movies one frame at a time. Unless of course you are one of the proud fathers. When Robby reached the other side of the mound—five hours later—everyone was grinning. "Rather than hoping it would work fast," Wilcox says, "we were just hoping it would work at all."

Robby still needs plenty of work. He can recognize deviations from a flat plane, but not their nature or composition. He therefore can't tell if the terrain ahead is solid or actually loose dust that will collapse beneath him. But the JPL team is hopeful that Martin Marietta's current experiments with ground-penetrating radar, which can determine soil density, will prove a useful addition to Robby's brains. "The radar isn't perfect yet," Wilcox admits, "but it's coming along."

Progress has been made on other fronts. Changes in Robby's software and the addition of a special image-processing computer enabled him to cover over 300 feet in four hours during a test last September. And Wilcox expects Robby's top speed to eventually reach two miles an hour.

But other key items are still under development. JPL's mechanical engineering group is working to increase the stability of Robby's mobility system, which consists of three body segments hitched like trailers that can tip over on rugged terrain. A further complication is that here on Earth, Robby's gasoline generator works quite well, but it won't stand a chance on Mars. A powerful nuclear device will be the actual "engine," but it can't be tested here since, as Wilcox notes, the radiation from it would endanger everyone in the test area.

To further Mars-proof Robby, some sort of "dry" lubricant, like molybdenum disulfide, will have to substitute for the motor oil that he currently uses, and the rubber wheels will have to be replaced by something that won't shatter in the extreme sub-zero temperatures. "We're thinking along the lines of the Soviet engineer who once drew up ideas for some sort of flexible metal wheel," says Donald Bickler with

a hearty grin. "What the hell? We'll steal from anybody."

There was nothing out there for Carnegie Mellon University to steal from, even if it had wanted to. After initially kicking the tires of some wheeled ideas, CMU decided to try Ambler, a walking machine with six legs. A few other rovers have been designed as walkers, but Ambler's stilt-like legs are a true innovation. "From the start, NASA encouraged us to free ourselves from the conventional wisdom of programs that had gone before," says William "Red" Whittaker, director of CMU's field robotics center. "To be able to not only move efficiently but also do the digging and drilling for the sampling, we knew we needed a combination of finesse versus brute force, of cognizance versus blind groping. Something that would give us the best rate of advance with the least amount of energy."

They looked at the technology of earlier legged machines, the wave-gait of centipedes, the traction challenges of mountain climbers—and they did a lot of pure brainwork. The result is an aluminum arch frame resting on a pair of stacked, pole-like legs, three per stack, which swing themselves one at a time through the arch, plant themselves on the ground, and then pull the machine forward. The action, which looks like two incredibly slow eggbeaters applying the motion principle of cross-country skiing, allows Ambler to gracefully muscle itself over most obstacles. And the vertically adjustable legs keep Ambler balanced and level on most inclines up to 30 degrees, no small concern if deep drilling is necessary at such a location.

Ambler's navigation system consists of a laser rangefinder that draws a detailed, three-dimensional map of the vicinity. There are also sensors in the footpads that can quickly tell if the ground will support Ambler's weight. The central control computer, which can process some two million instructions per second, studies the data, chooses a direction, then decides where to place the feet for each step.

Everything about Ambler seems to exist on a huge three-dimensional grid. Inside its large warehouse home is a rectangular floor space where Ambler normally rests, a control center parallel to the floor space, a sandbed (simulating uneven terrain), and an overhead lattice of beams and cables.

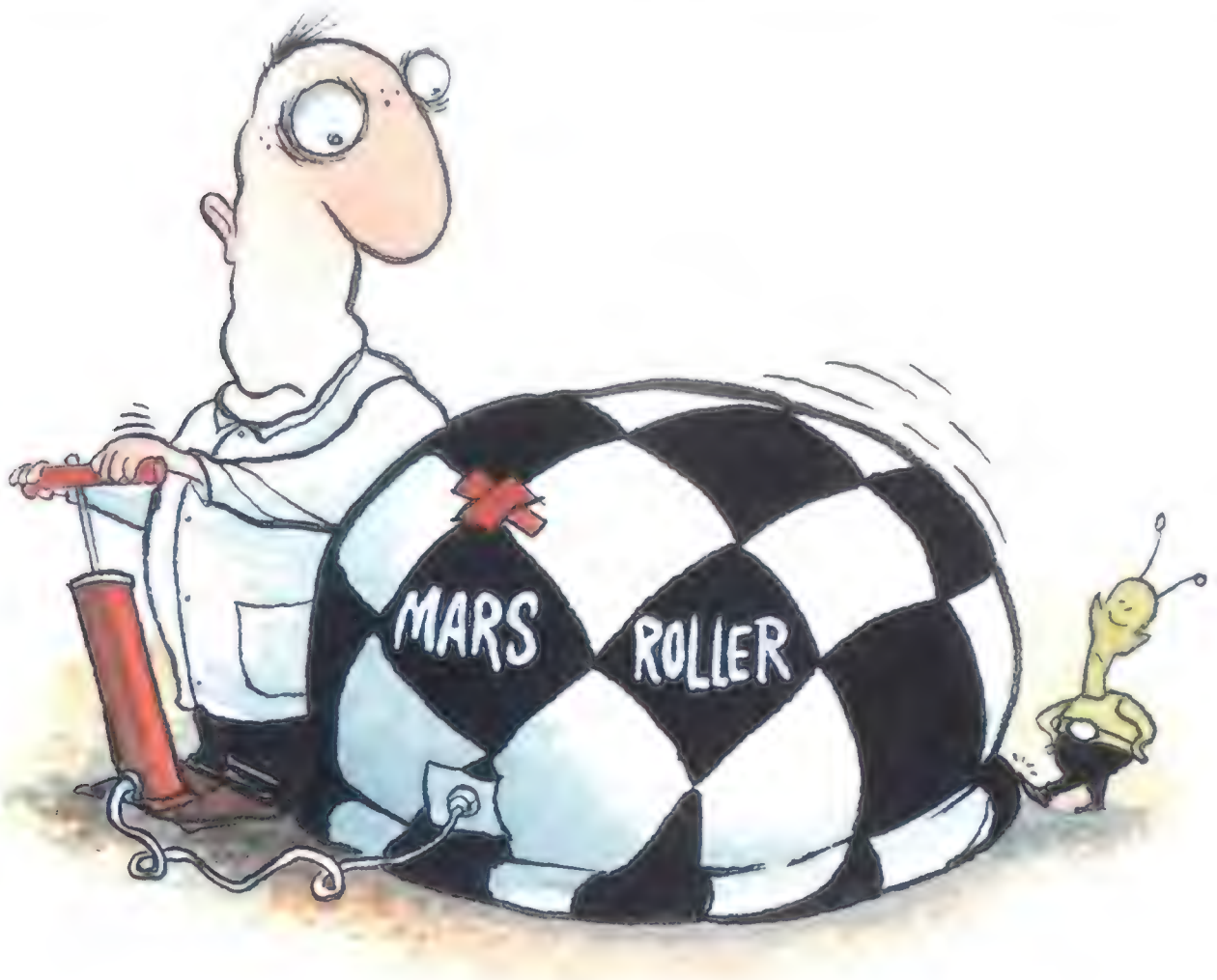
The grid is most evident when Ambler moves. Last December a group of NASA observers came to the warehouse for a demonstration of its mobility and, even more impressive, its ability to think for itself. The sandbed had been curtained off like a stage, and the usual obstacles of trashcans and crates had been replaced with genuine boulders. A computer cable tethered to the top of Ambler's frame ran along a beam and down into the control center, where a programmer booted up software, then keyed in the command: Cross the bed and all its rocks, slopes, and ditches.

After a few minutes of calculating and calibrating, Ambler began to execute, and you could almost see a blueprint framing each movement. A "hind" pole leg slid up vertically, stopped. It rotated forward through the arch, stopped. It slid down, planted on the sand. A second leg slid up, stopped, rotated, stopped, planted on a slope. A third rotated and planted in a ditch, a fourth in the sand again. Then, the Ambler having staked its position, its legs at various heights, the perfectly level body of the machine slid forward, the horizontal movement immaculate.

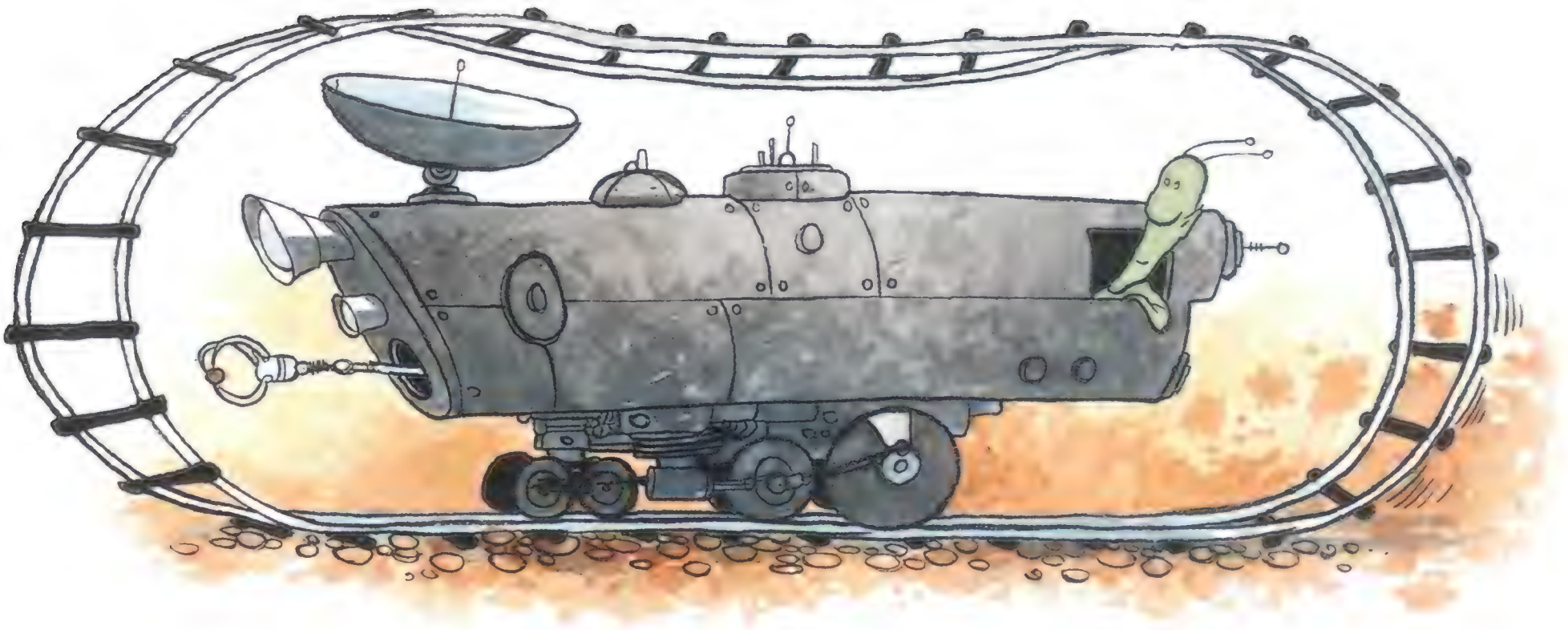
Detailing the action to the observers was Whittaker himself, a tall, broad-shouldered man big enough to have been a football player in the years before his red hair thinned out. "It's sort of like a chess game," he expounded. "You can only move one leg at a time, and where you move one leg determines where you'll move others. So you have to think several moves ahead all the time."

Though Ambler has conquered the three-foot chasm and obstacle requirements, it still needs about as much work as Robby. The navigation system is about 75 percent complete, but the nuclear power source and the drilling and coring equipment have yet to be designed. As for the "oil" problem, CMU is considering developing magnetic bearings and low-friction rack-and-pinion assemblies that require no lubrication at all, wet or dry.

For now, Ambler remains in its concrete warehouse on CMU's campus, tethered by computer cable to an operating board. Its designers continue to hope that one day, Ambler—or something like it—will stalk freely over the surface of another world.



After all is said and done, which should you bet on, Robby or Ambler? Depends



on whom you ask. Says CMU's Whittaker, "Basically, Robby is a bad copy of work done 25 years ago." Says JPL's Bedard, "Theoretically, a walking machine is more terrain-adaptable and more energy-efficient, but"—he pauses with a wry grin—"this has never been proven in space."

What does NASA think? "You don't want a wheeled vehicle trying to work in terrible terrain," says Lavery. "It would never be able to get around well. But on a relatively flat, smooth area you wouldn't want legs because they're too slow compared to wheels." Even Robby's grandmotherly quarter-mile-an-hour speed would, on a smooth straightaway, blow the doors off Ambler. But then, Robby's wheels use up far more energy than Ambler's legs.

NASA may have to choose between mileage or speed, but not any time soon. No one's going to decide on anything before both prototypes are fully operational. "We have no intention of taking either vehicle as is directly to flight-qualification," says Lavery. "We're just trying to test and prove different technologies at this point. All we want to know is: How different can we make these approaches so that we can get the widest possible baseline of options and possibilities? What I expect to happen is when time comes to build flight-qualified hardware, we'll pick pieces of both approaches and integrate them into some kind of hybrid." (The robots CMU created for Three Mile Island are equipped with both wheels and legs.)

Yet one of the concepts may well dominate the final design, and economics and efficiency will not be the only deciding factors. As Wilcox ruefully points out, "To some degree sex appeal will be involved too." As cars have their allure, so do planetary rovers. In the words of one NASA official, "Watching Ambler move is like a religious experience. Watching Robby doesn't really inspire you to write your congressman and say, 'Throw money at NASA!' "

Another possibility is that after extensive deliberations and exhaustive comparisons, NASA might simply conclude, "Oh, heck, we'll take both." Because different planets have different terrain, says Lavery, "We may end up with a series of different machines." Assuming the money is there.

Unfortunately, money for the rover program was shot down from an expected $12 million to $3 million in the 1991 budget wars. Though costs for the development phase alone are expected to run at least $40 million, NASA has received only $7 million to date. And since the program received no additional funding for 1992, NASA will have to dip into existing funds—just enough to keep both programs squeaking by.

"Originally we planned to launch a vehicle by 1998," Lavery says. "But given what's happening with the budget, it's not even possible to guesstimate a new date now. Will it eventually happen? Yes. But an exact date? That's a toughie."

Such is a space designer's lot in life. Says Wilcox the realist, "We figure there's at best a fifty-fifty chance of seeing a rover mission during our lifetime."

And it may not even be a U.S. rover. The Soviet Union is interested too; in 1971 it launched a rover-equipped probe to Mars, but the mission failed when controllers lost contact with the probe two minutes after it landed. More recent designs suggest a somewhat Freudian influence. The centerpiece of the Soviets' 1994 mission to Mars is a rover that sports six conical tires and a "vibro-penetrator" that can core up to a depth of 30 feet. Another system is the "snake-balloon," designed to take meteorological samples by day, then descend at night for the snake—a tail packed with sensors—to take surface measurements as it drags the ground.

Whatever creature makes it to Mars, be it American or Soviet, a walker or a roller—or some combination of both—it must be self-reliant. As Whittaker observes, "There ain't no AAA tow truck gonna bring this thing home if something goes wrong up there."

WIZARD.

NOTHING CAN HELP YOU TAKE CONTROL OF ALL THE DETAILS OF YOUR BUSY LIFE LIKE THE WIZARD® AND ZQ SERIES ELECTRONIC ORGANIZERS FROM SHARP.

INTRODUCING THE WIZARD® 8000.

The OZ-8000 is a powerful yet uncomplicated computer that fits in the palm of your hand. Our new "Help" key provides step-by-step instructions for each function. Eleven built-in features include a Text Outliner and Business Card File. A raised keyboard and 40 character, 8 line display make it easy to enter, sort, and retrieve information quickly. You can even back up your data in seconds on an optional memory card.

THE POWER TO ORGANIZE YOUR BUSINESS AND PERSONAL LIFE.

ZQ-2000
12 Character x 4 line display.
Exchanges data with other Sharp organizers.
16K memory.
Shirt pocket sized.

ZQ-2200
12 Character x 4 line display.
Exchanges data with other Sharp organizers.
32K memory.
Shirt pocket sized.

ZQ-3000
16 Character x 4 line display.
Shirt pocket sized.
9 built-in functions.
32K memory.

ZQ-5200
16 Character x 8 line display.
Shirt pocket sized.
9 built-in functions.
64K memory.

WIZARD OZ-7000
16 Character x 8 line display.
Software expandable.
32K memory.
(ROM cards available for functions shown.)

WIZARD OZ-7200
16 Character x 8 line display.
Software expandable.
64K memory.
(Optional Money Planner software shown.)

MORE SOFTWARE. MORE FUNCTIONS.

All Wizard and ZQ series electronic organizers come with a complete array of built-in functions. With the OZ-7000 and 8000 series, you can also expand both applications and memory with Sharp's extensive library of optional software cards. Create a spreadsheet. Calculate loan payments. Track your expenses. Even send a fax directly from your Wizard.

And through Sharp's patented touch-screen technology, each card has its own custom keyboard for easy operation.

This symbol indicates software expandability.

THE PC CONNECTION.

The Wizard can be a portable extension of your home or office computer. With optional PC-link software and cable, you can swap files with any IBM® compatible or Macintosh® computer.

And an optional modem sends and receives data right over the phone lines.

This symbol indicates PC-link capability.

For a free brochure on Sharp's Wizard or ZQ series electronic organizers, or for the store nearest you, call 1-800-321-8877. In Canada call 1-416-890-2100.

SHARP.

FROM SHARP MINDS COME SHARP PRODUCTS™

by Jay Stuller

When you're a solar forecaster, it's always flare weather.

SUN STORMS

In San Francisco, garage doors opened and closed mysteriously. In Montreal, burglar alarms went off for no apparent reason. From coast to coast all across North America, electrical appliances on March 13, 1989, seemed to be auditioning for an episode of "The Twilight Zone."

But that was nothing compared with what happened to Quebec's vast hydroelectric system. Massive electrical currents swamped transformers, and within seconds the entire system collapsed, blacking out much of the province for nine hours.

The disturbances weren't limited to the ground. Shortwave transmissions were interrupted, a Coast Guard navigation system was overwhelmed, and the U.S. Space Command, which monitors some 19,000 objects in space, lost track of more than a third of them.

High above earth, the Solar Maximum satellite dropped half a mile. A Department of Defense satellite began spinning out of control, and hundreds of commercial satellites were adversely affected as well.

At the Space Environment Services Center in Boulder, Colorado, U.S. Air Force master sergeant Norm Cohen had heard the first alarms that signalled the trouble to come. Following routine procedure—albeit a bit more urgently—he made a quick series of telephone calls, alerting the Air Force, satellite controllers, the Federal Aviation Administration, and utility companies. "We have an X-class flare," Cohen reported.

Some 93 million miles away, in a region of the sun known as 5395, one of the largest solar flares in recorded history had burst from the surface of earth's nearest star. Loops of incandescent gas leapt tens of thousands of miles into space. The result was an enormous shock wave of energy that slammed into the earth's atmosphere.

"The sun is like a spinning garden sprinkler," explains the SESC's chief forecaster, Joe Hirman. "If a flare goes off in the right place on the sprinkler—where it's in a direct line to the earth—a powerful burst of X-rays, ultraviolet radiation, and radio noise traveling at the speed of light can reach here in less than nine minutes." The results can lead to electronic hijinks—and far worse. Had the 1989 storm hit in the summer, when the power system is under more strain from air conditioners, "the whole Northeast would have gone down," says Hirman.

It's up to Hirman and his forecasters to monitor the sun and provide warnings of solar activity. Trying to track the weather on a star isn't easy. Not only are the physics not well understood, once the phenomena leave the sun's surface, they are invisible. "It's impossible to forecast with complete accuracy, so at times this job is frustrating," says Cohen. "If something does happen, though, we're the first to know it."

Working in the shadow of Colorado's craggy Flatiron mountains, the SESC staff of 70 gets most of its information from the GOES satellite, in geosynchronous orbit 22,300 miles up. The forecast center also relies on the National Oceanic and Atmospheric Ad-

MCALLISTER OF DENVER

At the Space Environment Services Center, Air Force technical sergeant David Rose analyzes the sun's magnetic fields for a solar weather report.

NOAA

The camera makes it appear closer, but the sun is really a comfortable 93 million miles away. Even from that distance, solar flares can play havoc with terrestrial electronics.

ministration's (NOAA) polar-orbiting satellites, as well as satellites operated by the defense department. Round-the-clock reports arrive from observation stations around the world: Australia, Greenland, Western Europe, India, Japan, and the Soviet Union. The forecasters can also use a solar telescope on the roof of the SESC's four-story concrete building.

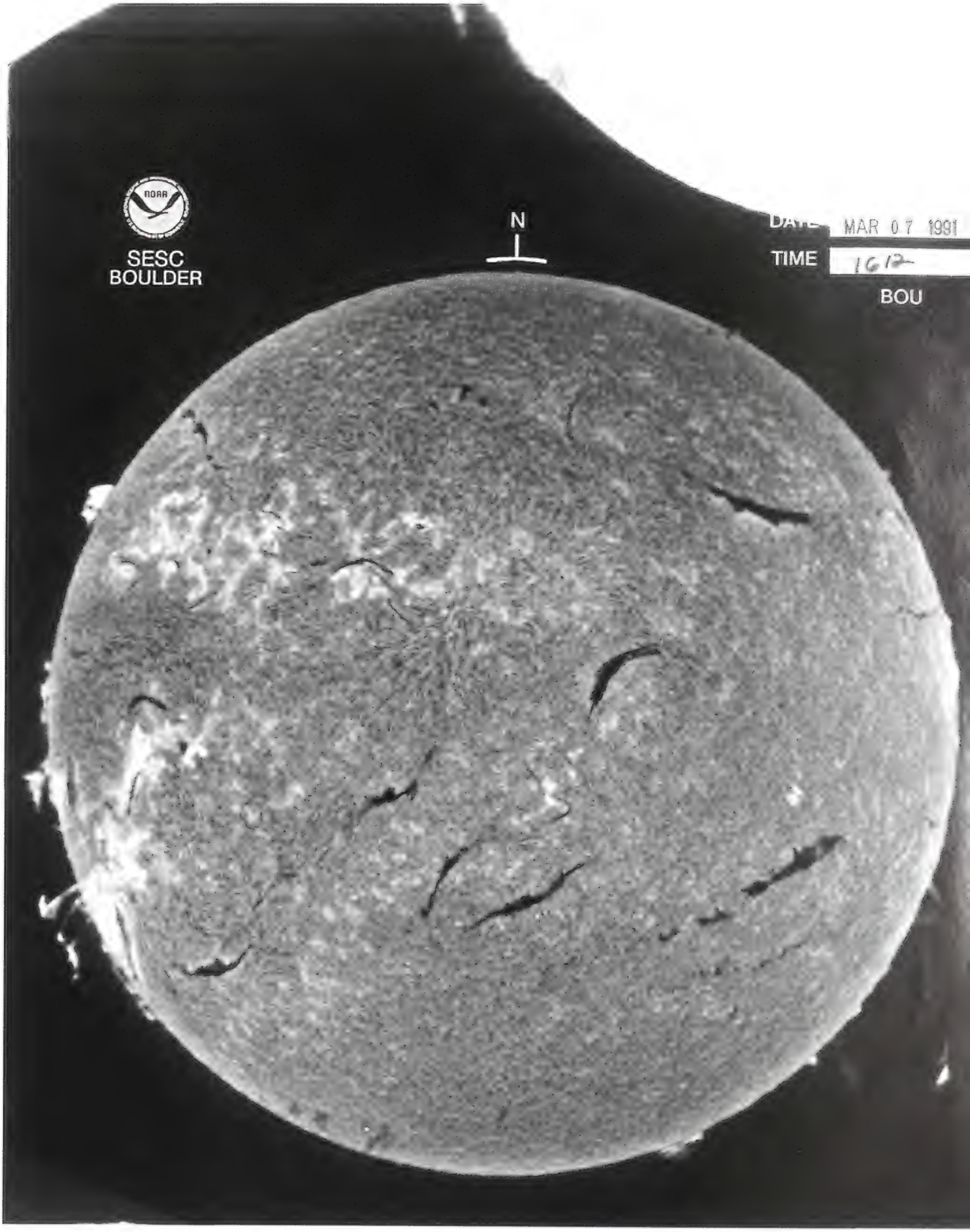
The Boulder locale contributes to a laid-back atmosphere at the center, and casual civilian attire mixes easily with Air Force blue. In addition to doing research on solar phenomena, the SESC develops sensors and other hardware for satellites and ground monitoring stations. But its primary job is monitoring the sun. Every three hours the center broadcasts summaries and forecasts of solar and geomagnetic conditions. It also prepares daily, weekly, and monthly reports.

Initially intended to meet critical military needs, the SESC was established in 1942 as the Interservices Radio Propagation Laboratory under the Department of Commerce. After World War II, it continued to operate for civilian purposes in various guises: the Central Radio Propagation Laboratory, the Space Disturbances Laboratory, and the Space Environment Laboratory. Since 1970 it has been run by NOAA and the U.S. Air Force.

Despite the center's long history of service, says Hirman, today "relatively few people, aside from those in the scientific community and those who use our service, are even aware of the potential damage from solar storms." That may change in the coming years as our world becomes increasingly dependent on electronics—and therefore finds itself increasingly at the mercy of solar weather.

Back in late 1957 and early 1958, a series of solar flares—some of the largest barnburners on record—knocked out a handful of utilities; if a storm of that magnitude occurred today, it would be far more devastating. Money and commodity exchanges move worldwide through satellite links. And aviation and marine safety depend on reliable communications and navigation systems.

The high-energy protons that flares initially emit could also endanger space travelers. One flare erupted in August 1972, after the Apollo 16 mission and before the Apollo 17 launch. Had that flare occurred four months earlier or

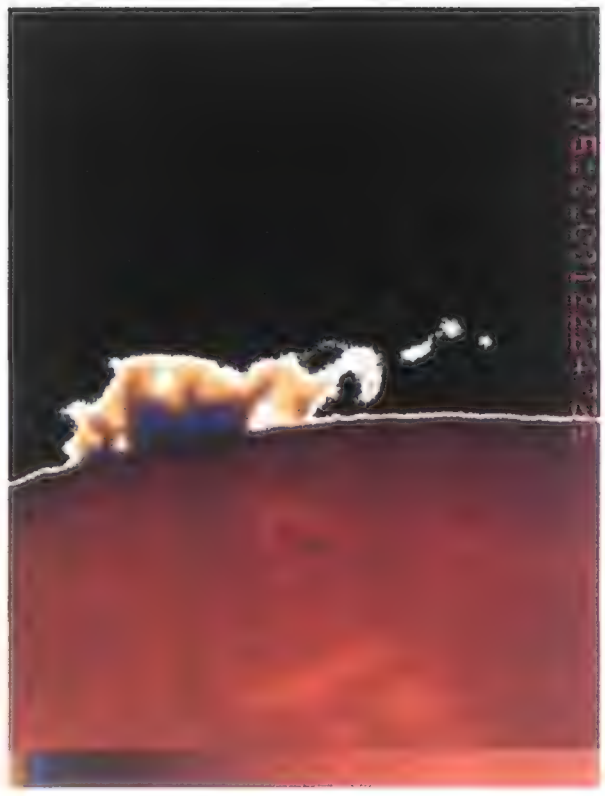

NOAA
SESC
BOULDER
N
DATE MAR 07 1991
TIME 1612
BOU

four months later, astronauts might have died. "This place really came together because of the space program, when NASA grew concerned about the effects of space radiation on astronauts," says Hirman.

"This is a big question about a manned mission to Mars that really hasn't been answered," he continues. "How much shielding—and what kind—will protect the astronauts?" An aluminum lining or tanks of water have been suggested to protect space travelers, but the astronauts would still need warning to reach the shielded zone before a solar event.

For shuttle astronauts, such disturbances pose only a moderate risk. Particles from solar flares are strongest near the polar cap and at higher latitudes, where the particles tend to spiral into the planet's magnetic field. On most missions, the shuttle travels at a relatively low inclination to the earth's equator, and the planet's magnetic field acts as a protective shield. The SESC gives NASA a forecast two hours before every shuttle launch; should a mission's orbit be headed for a higher inclination, a major flare could force a scrub. In addition, "having a general idea of the solar cycle helps them to plan shuttle payloads," says Hirman. "If it appears that a lot of solar activity will heat and expand the atmosphere, payloads will have to be boosted into higher orbits."

It's not certain whether a proton swarm from a large flare could endanger an airliner traveling at high altitudes in northern latitudes. One forecaster says he doesn't give it a second thought, while another says he would avoid polar route flights for a day or two following a big flare. Occasionally the SESC gets inquiries from prospective airline passengers. Charliss Carpenter, a solar technician who joined the center in 1986, remembers a pregnant stewardess who called before flights and asked, "Do you have any protons going on?"



NOAA

A gaseous eruption known as a prominence arches off the outer disk of the sun in this false-color image.

Another group of fliers who suffer the consequences are pigeons. The birds' legendary homing abilities are thought to be due to a concentration of the mineral magnetite close to the central nervous system, which serves as an internal compass. A solar flare can send those compasses spinning. During a geomagnetic storm in June 1988, a group of British pigeon fanciers launched about a hundred birds on a race from France across the English Channel, and almost none of them made it back home. ("A lot of our scientific types get embarrassed about the pigeon thing," says Hirman.)

In a sense, the center's forecasters are spiritual descendants of the Stonehenge architects, the Egyptian pyramid builders, and the Aztec worshippers of the sun god Huitzilopochtli. Like the ancient skywatchers, the solar technicians keep tabs on the dominant body of our solar system. A "main sequence" star, our sun generates its energy through fusion—the merging of hydrogen atoms to produce both helium and energy in the form of visible light, ultraviolet rays, and X-rays.

Throughout its 4.5 billion-year life the sun has remained remarkably consistent in its energy output. But the sun does experience cycles of activity. Records of these cycles date back to 1760; we are currently midway through cycle 22. Each cycle is marked, usually on the average of every 11 years, by an increase in the number of sunspots. These dark splotches on the sun's surface were first identified around 1610 by Galileo and others with the newly invented telescope. Some sunspots are so large that at sunset they can be seen with the naked eye.

Sunspots are thought to be produced by tremendous currents of electricity in the sun's interior. According to the

MARK SHERIDAN

A photo of the sun's full disk, taken in the hydrogen-alpha wavelength, depicts several major flares (left).

Uniforms mix with casual attire at the SESC's daily briefing, where forecaster Joe Hirman addresses the staff.

1873 formulations of Scottish physicist James Clerk Maxwell, any motion of an electric charge generates a magnetic field in its surrounding medium (and conversely, any motion of a magnetic force induces the flow of an electric current). Unlike the earth, which is a solid body that rotates as a whole, the sun is essentially a body of gaseous layers that rotate at different rates. The variation in rotation, combined with the large circulation patterns of the gases, twists the magnetic fields and drives them to the surface in the form of sunspots.

The peak of activity in a solar cycle, known as a solar maximum, occurs when sunspots erupt into an increased number of solar flares. These enormous gaseous eruptions might be set off by the interaction of magnetic fields of opposite polarity. Solar flares come in a variety of forms—ribbons, streamers, arches, and loops—and are ranked (in ascending order by a factor of ten) B, C, M, and X, according to their X-ray output. The energy released from one X-class flare would be enough to provide electricity for the entire planet for the next million years.

When the first shock wave of X-rays from the March 1989 flare struck our atmosphere, it altered the densities of electrons and ions distributed throughout the daylight side of the ionosphere, the electrically charged atmospheric layer where radio waves are propagated. (The night side is shielded and unaffected.) Nearly all shortwave, high-frequency communications faded into static. This initial wave was followed by a mass of accelerated high-energy protons, which can penetrate the shielding of spacecraft and produce a charge in semiconductors that overloads electronics—the effect that stunned the Solar Max satellite. Satellite controllers can usually correct such problems. But they are more helpless when the electric currents from a geomagnetic storm

The polar light displays known as aurora borealis *are the most spectacular result of interactions between the sun and earth's magnetic fields.*

GEOFF CHESTER

heat the upper atmosphere, causing it to expand into the path of orbiting satellites. The increased drag can pull a satellite out of its altitude, set it rotating too fast, or knock it from its position.

About three days after the wave of high-energy protons, a swarm of lower-energy protons, electrons, and magnetic fields from the sun arrive "like they're riding on a freight train," according to Hirman. The result is an agitation of the earth's magnetic field called a geomagnetic storm. The disturbance changes the density of the ionosphere, impairing communications, navigation, and tracking systems. Geomagnetic storms can also induce surges of current in metallic objects, such as pipelines and power lines. With enough warning, utility companies can usually prepare their switching systems, but sometimes the surges still overwhelm the system, as they did to Hydro-Québec in 1989.

About two-thirds of the SESC's customers are concerned about perturbations in the planet's magnetic field, so the forecasters often consider geomagnetic forecasts more important than flare activity alone. "A flare is easy to spot," says Norm Cohen. "But magnetic activity can also come from filaments that disappear, from holes that open in the sun's corona or outer atmosphere, or will grow unsettled for seemingly no reason at all."

Disturbances in the geomagnetic field can also produce more benign effects. Electrons accelerated during these disturbances fall into the earth's magnetic field lines near the poles and collide with atmospheric oxygen and nitrogen, resulting in the colorful polar lights known as *aurora borealis* and *aurora australis*.

The solar telescope looms behind chief observer Larry Combs as he draws sunspots to track their progress on the rotating sun.

"Hello, what's this?" As Charliss Carpenter watches, a monitor that measures X-ray flux suddenly goes *ding dong*. A purple line crawls upward on her computer screen, indicating a rise in X-ray intensity. "Could be a flare on the west limb," she says, referring to the western side of the visible edge of the sun. She calls the Federal Aviation Administration and various satellite controllers, while Cohen calls the Air Force's Global Weather Central in Omaha, Nebraska, which serves the defense department. Fortunately, the flare proves insignificant; it's only a low-level alert.

Surrounded by monitors in the operations room, Cohen processes data for his daily forecast and a seven-day outlook. "In a few days, region 6272 will be rotating around the east limb," he says. "The last time around it showed a lot of spots and produced a flare per day, including eight C-class and three M-class. If it goes off in the right place at the right time, you can get a lot of protons from an M-class flare."

Like regular weather, the extraterrestrial climate is difficult to predict. Cohen expects 6272 to jumble the geomagnetic field, "but I'm not forecasting it yet. Who knows what can happen to a sunspot group while it's on the other side? Until I can really see it, it's only a factor in what might be a trend. I think that the more complex your analysis, the better the diagnosis, which gives you a better prognosis for an accurate forecast."

When the sun is quiet between big flares, life at the forecast center can become somewhat humdrum. "Oh sure," says Cohen, "during a solar minimum it can get really boring, sitting here for days without seeing one spot, the sun as smooth as a billiard ball." But inevitably celestial fireworks start up, and the solar forecasters have a front row seat. Air Force technical sergeant David Rose won't forget the flare of March 1989. He had just finished a three-year stint in the Italian town of San Vito, a tour of duty so uneventful he started thinking about quitting solar forecasting. "To see that big flare in progress for two hours made everything worth it," he says.

With an increase in solar storms expected during the waning of cycle 22, the early 1990s should be anything but quiet. Electric companies are working with NOAA to develop a satellite that by next year or the year after would provide earlier warning of impending solar storms. Positioned a million miles from earth at the L-1 point—where the gravitational pull of the earth and sun are balanced—the satellite would include a magnetometer and a plasma analyzer to monitor solar activity. The investment would not be hard to justify. Had the northeast power grid gone down during the 1989 flux, repair costs could have been as high as $6 billion.

Already this year the SESC has observed eruptions of the largest solar flares since the 1989 storm. The biggest occurred in January, but its position on the sun's surface made the effects uneventful. In late March another flare forced a NOAA weather satellite to automatically switch to its backup attitude control system. This is probably just a hint of what is in store for the folks at the SESC as solar activity continues to peak. "The storms," says Cohen, "make life interesting for us."

Offbeat Landings

Some airplanes end their days in the strangest places.

Photographs by Chad Slattery

Text by Karen Jensen

It might seem an ignoble end for one of the legendary Flying Fortresses, but for Art Lacey, the purchase of the B-17 was a stroke of genius. In 1947 Lacey paid $13,750 for the factory-new Boeing after the U.S. Army Air Forces declared it, and hundreds like it, surplus. Mounted on

Even above gas pumps, the B-17 at Bomber Gas in Milwaukie, Oregon, looks stately. From the regal to the whimsical (above), airplanes have lent an exotic touch to the commonplace.

Intended as a pilots' fly-in restaurant, Tom Pierce's Convair 990 (left) has been closed for over a year. Unless he finds someone willing to re-open it, Pierce, who operates the Tri-County Airport north of Denver, will convert the airliner to office space.

The BT-13, or "Vultee Vibrator"—here mounted above a Caruthers, California gas station (right)—was scrapped in large numbers following World War II but is now making a comeback among restorers.

four pylons at Lacey's Bomber Gas service station in Milwaukie, Oregon, the B-17 went on to become a local landmark and made Lacey, in his words, "a wealthy old man."

"As far as all of us out here were concerned—Boeing being right next door—it was the B-17 that won the war [in Europe]. So if I could get one, I figured I had it made," says Lacey, 78. "I did, and it was."

When photographer Chad Slattery spotted the bomber in 1986 he decided to track down other airplanes being used for purposes distinctly different from what their designers had intended. Over the years he gathered leads from people he met in his travels and logged countless hours on the phone pursuing them.

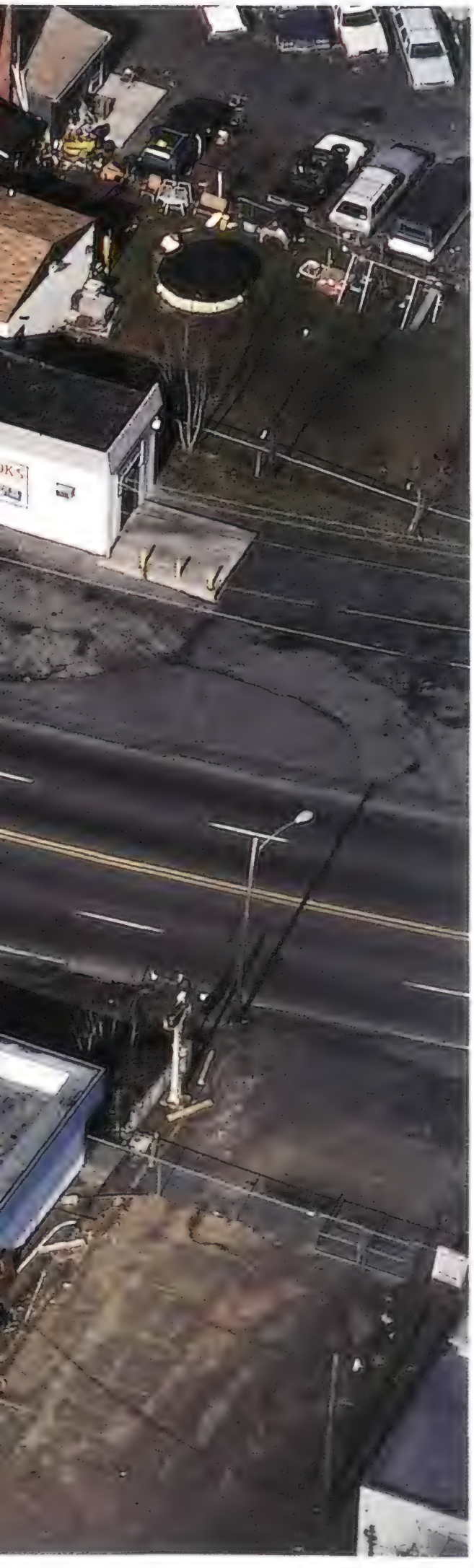
The majority of his finds turned out to be airplanes that either decorated

Frozen in a gentle climb, a 1947 Stinson gives an air of adventure to a Banana Republic clothing store in Beverly Hills.

Judging from its assemblage of spare parts, a gaily painted airplane affixed to a Nogales, Mexico pizza parlor (left) seems to have been designed to crash.

restaurants or *were* restaurants—a curious pairing, given that airplanes and fine dining often seem mutually exclusive. Indeed, a sign near a Convair 990 airliner converted to a diner in Erie, Colorado, boasts, "Your first good meal in a plane." Jimmy Magg's, a lounge and restaurant directly beneath the final approach to Boston's Logan airport, has what appears to be a crashed Piper Cherokee 140 on its roof, and pilots flying in the area regularly call in to report the "accident." And Art Lacey, whose "Bomber Complex" already contains a motel and a restaurant, is considering doing away with the gas pumps altogether and moving his restaurant beneath the B-17's sheltering wings.

More often than not, however, Slattery's research led to disappointment. He'd arrive at a site only to discover that the airplane had



KELLY/MOONEY

been scrapped or abandoned. Some of the airplanes had vanished for practical reasons—several that decorated buildings in Los Angeles had been removed because they presented earthquake hazards—but the majority seem to have fallen victim to the changing whims of fashion and taste. "Planes on roofs don't go with 1980s postmodernism," is how Slattery sees it.

"Partly it's a pop culture phenomenon, and pop culture's just not as interesting to us today as it was 20 years ago," says architect Neil Payton, an assistant professor at Catholic University in Washington, D.C. "I also wonder whether or not we have a love of airplanes as we once did," he adds. "I think that in the last 10 to 15 years air travel has lost its cachet. When air travel was an exotic thing, using an airplane for another purpose was also a way of bringing this element of the exotic to everybody."

Though these curiosities are rapidly vanishing, the news is not all bad: occasionally one of these flightless aircraft goes on to better things. A Boeing KC-97 tanker converted to a restaurant at the airport in McMinnville, Oregon, seemed destined for scrap when the restaurant closed for good in 1988. Fate intervened, however, in the form of a Greybull, Wyoming firebombing operation that still flies KC-97s. A team of the firm's mechanics descended upon the airport, and late last year the former restaurant left its confines—not in boxes, not in tow, but in the air.

A mock World War I fighter met its match in a California amusement park rather than the skies above France.

Want a Constellation? The Penndel, Pennsylvania bar (left) has been for sale since closing three years ago.

Not all winged decorations are campy delights: an F-104 on L.A.'s Aerospace Museum epitomizes beauty and power.

Beyond the Shuttle

The orbiter fleet won't be around forever, but what should take its place?

by Linda Shiner

Illustrations by Paul DiMare

For the U.S. space shuttle, 1990 was a very bad year. Just when it looked as if the launch system would finally hit its stride, nettling leaks in the hydrogen lines of two orbiters put the shuttle program on hold for five months. It was yet another demonstration that shuttle operations are anything but routine. NASA projected nine launches for last year; it delivered six.

While technicians at the Kennedy Space Center were struggling with the shuttle's plumbing, a commission in Washington was deliberating its future. When the Committee on the Future of the U.S. Space Program, chaired by Martin Marietta CEO Norman R. Augustine and known as the Augustine committee, released its report last December, it called the shuttle "the weak link of the civil space program." The committee urged the Bush administration to "promptly establish and fund a firm program for development of an evolutionary, unmanned but man-rateable, heavy lift launch vehicle."

In other words, it's time the shuttle found an heir.

There will be no shortage of candidates. Designs for launch systems are coming from every quarter. Some of them could be ready before the end of the decade; some will take a little longer. All have at least one thing in common: a claim to be less costly and more reliable than the space shuttle.

As NASA's Congressional oversight committees debate life beyond the shuttle, they must consider a number of questions. What has the past decade of shuttle operations taught us about the benefits of reusable versus expendable systems? What are the advantages of a purely reliable launch vehicle over a high-performance one? Can the United States continue to compete for international space launch customers with expendable rockets—Titans, Atlases, and Deltas—based on 1950s technology and a shuttle designed in the '70s? If not, can we turn to a new launch system, or do the necessary technologies lie too far in the future?

Already, the Bush administration has requested $350 million from Congress to accelerate a NASA-Air Force program to build a new rocket. Already several congressmen have hinted that they will turn down the request. "It may be just another paper chase," says Hubert P. Davis, a former NASA engineer who worked at Johnson Space Center in Houston for 17 years and was a supervisor for the Apollo program to build the lunar module. "Of course, even if it is, we're all ready to jump in."

The New Launch System

When Ronald Reagan announced the Strategic Defense Initiative in 1985, the Air Force went looking for a "big dumb booster" it could use to launch SDI's skyful of anti-ICBM weapons. The result was the Advanced Launch System, a whole family of rockets based on a common expendable core.

In the meantime, NASA had been working on a design called Shuttle-C, a shuttle spinoff that replaced the reusable orbiter with an expendable, unmanned payload canister. Although NASA had contributed to the ALS, the agency preferred Shuttle-C because it offered greater lift and a smaller sticker price. However, its operational costs would be mighty, since 95 percent of the subsystems are identical to those of the manned shuttle.

Pushed into a shotgun wedding by Congress and the National Space Council, NASA and the Air Force came up with a launch system that combined elements of both designs. The new vehicle was christened the National Launch System (and is now being referred to as simply the New Launch System), but the ALS is definitely the dominant strain in the hybrid. Shuttle-C's contribution was limited to the gargantuan external tank, outfitted with engines and avionics to become the rocket's common core.

One of the designs poised to step in as the shuttle's heir is the single-stage-to-orbit craft.


GENERAL DYNAMICS
Millennium Express

Although it will be a purely disposable rocket on its earliest flights, the NLS won't be cheap—the system will cost as much as $10 billion. But unlike the high-strung, purebred shuttle, the crossbred NLS is designed for reliability, not performance. "We're not trying to build a race car," says Air Force colonel Roger Colgrove, who manages the NASA-Air Force joint program office for the development of the rocket. "We're trying to build a truck."

"What I want from a truck is something that's tough and rugged," says Donald Witt, the director of the NLS program at Pratt & Whitney Government Engines and Space Propulsion in Florida. (Pratt & Whitney is one of three propulsion companies teaming up to build the new engines.) "Every time I start it, it works. It doesn't have to be advanced if it does the job and hauls the load."

Though once billed as a "space truck," the shuttle is to trucks what a Lamborghini is to a family car. Its main engines use staged combustion, a cycle in which all the rocket's fuel is first burned with only a fraction of its oxidizer, producing a low-temperature gas to power high-pressure pumps. The pumps then send the gas and the remainder of the oxygen to the combustion chamber for the second stage of burning. In this cycle, "every ounce of propellant has to end up in the combustion chamber," says Witt. Moreover, it has to get there at tremendous pressures in order for that engine to achieve its required specific impulse, a measure of performance roughly comparable to a car engine's miles per gallon.

The rocket engine that Witt is working on will have a less efficient combustion cycle called a gas generator cycle, of the same type used by the Saturn V moon rocket. The engines will have a lower specific impulse and a lower chamber pressure. "The pumps and turbines don't have to work as hard. I can run the pumps slower, run the turbines at a lower temperature," says Witt.

The less sophisticated cycle also enables the number of parts to be dramatically reduced. "That's the really big thing in reducing cost and improving reliability," says Witt. "Because of the efficiency required of the space shuttle main engine, the propellant injection system has to produce a very fine spray. The injector alone has something in excess of a thousand parts. This engine won't have quite as fine a spray. Its injector has three parts." And those parts will be heavy but cheap.

Everything in the NLS is designed to ease the strain and cost of operations instead of increasing performance. "So the rocket gets bigger—who cares? Fuel's cheap," says Colgrove.

The Consort's Contribution

Don't refer to the shuttle as a "space truck" when talking to Hubert Davis. "It is not a truck," he says. "It is the world's finest means of placing people into Earth orbit, little more. It carries a great burden by being much too large to serve this high purpose. That single attribute has contributed greatly to our collective disappointment in its utility for either purpose."

Davis wasn't happy with what had happened to the shuttle during its design phase. Because NASA needed the Air Force for a partner, the space agency had to accept the stipulation for a larger shuttle with a 15- by 60-foot payload bay. "We didn't like it but we did it," says Davis.

Immediately after *Challenger* exploded, Davis, who had retired from NASA seven years earlier, started work on his own version of a cargo carrier. He wanted to develop a heavy-lift cargo vehicle, but he didn't like either Shuttle-C or the Advanced Launch System. Shuttle-C would have used the shuttle's solid rocket boosters, which he says have at least two unacceptable characteristics:

Though not fully reusable, Consort could save its expensive engines for use on later flights.

they can't be shut down once they're started and they produce great quantities of hydrochloric acid. He disliked the ALS' intent to abandon the concept of reusability.

"The answer is not as simple as 'expendable' or 'fully reusable,' " says Davis. "More careful discrimination is required." So Davis designed the Consort, an unmanned companion to the shuttle that would use a reduced version of the shuttle external tank, plus shuttle main engines. Consort's self-returning engine module would recover those expensive engines for reuse.

Davis has approached NASA and the Air Force with the Consort idea, so far without success. But he wasn't as interested in selling the vehicle, he says, as in convincing his audiences to develop recoverable rocket engines.

Son of Shuttle

"The future of reliable vehicles will in large part derive from reusable systems," says Joe Loftus, assistant director for planning at NASA's Johnson Space Center. "The virtue that many of us see in a reusable system is that the system learns and we learn every time it flies. We get something back that we can look at and analyze."

As far as NASA is concerned, the next shuttle will almost certainly be completely reusable, use only liquid-fuel engines, and not come into use for at least 20 years. Beyond that, it's hard to say exactly what it will look like, although Theodore Talay of the NASA Langley Research Center can give you a pretty good idea of the possibilities. Since the mid-1980s he and his colleagues in Langley's vehicle analysis branch have been studying various designs for an Advanced Manned Launch System and have recently compared computer analyses of two-stage versus one-stage systems and air-breathing versus rocket designs.

What the vehicle will be "depends on when you need it," says Talay. "When we started looking at Shuttle II, we were looking at a high flight rate for the current shuttle, and we thought it would reach its retirement age by about 2005."

With that deadline, Talay considered an AMLS that would carry eight astronauts to a space station as well as a 40,000-pound module full of their supplies. Those requirements triggered an "automatic fallback" to a two-stage vehicle, Talay says, probably a reusable orbiter launched vertically on the back of a fly-back booster.

"There's a ripple effect in the design of a one-stage vehicle," says Talay. "The structures weigh more and require more propellants, which then require more structure. The weight growth is an exponential curve, and this is especially true if you're also trying to make it operationally desirable. When it's all fed into your sizing, sometimes the computer doesn't converge on a solution. You see the weight climb 7, 10, 15, 20 million pounds." The computer says in effect: "Start over."

Though once billed as a "space truck," the shuttle is to trucks what a Lamborghini is to a family car.

The scene has changed somewhat since Langley started this analysis. The space station has been reduced in scale to start operations with four astronauts instead of eight. And the shuttle has managed a much lower launch rate than predicted. "If the shuttle's going to do six, eight, ten flights a year, it can soldier on for quite some time," Talay says. Most NASA planners agree that a replacement for the shuttle won't fly until 2015. "Reducing the scale of the vehicle and permitting the introduction of more advanced materials tend to make the single-stage-to-orbit rocket more attractive," he says.

Enter the Air Breathers

Consider Talay's use of the word "rocket." Ever since Ronald Reagan announced the National Aerospace Plane program in his 1986 State of the Union address, the NASP's dazzling goals have made rockets seem as old-fashioned as horse-drawn buggies (see "Space Plane," August/September 1986). Scramjet engines that use atmospheric oxygen seem more elegant than propulsion systems that have to carry their own big tanks of oxidizer on their backs. And a horizontal-takeoff-and-landing spaceplane would seem to offer all the simplicity of an airliner. But NASA studies have also shown that air-breathing systems have their share of development penalties.

Talay's comparisons reveal that although rocket systems have a heavier GLOW (gross liftoff weight) than air-breathing systems, they also have a lighter dry weight—weight before fueling. "The dry weight is the important figure for development and production costs," says Talay. "The hardware is what you have to design and build. Propellants are cheap."

On the other hand, a spaceplane could leave the ground and fly "cross range" until it meets the orbital plane of an object it wants to intercept. A rocket, however, has to sit on the ground and wait for the orbital track to come past the launch site.

Whether a spaceplane could perform its feats on a routine basis is not at all clear, says Talay, who says there are no data to determine whether such a craft could really achieve the scheduling ease of the airlines. The unique propulsion and thermal protection systems in air-breathers may require even more care than the equipment on the tried and true rocket.

SDIO's Dark Horse

If the single-stage-to-orbit rocket does not become the shuttle heir, it should at least win a prize for unlikeliest-looking launch vehicle. With none of the tall good looks of a Saturn V, the single-stage-to-orbit rocket, at least in its vertical-takeoff-and-landing form, is the Roseanne Barr of rocketships.

The SSTO has followed a completely different line of development from that of its fellow rockets. Gary Hudson, one of the first rocket scientists in the country to design his own launchers and compete with the government for customers, came up with the idea of a single-stage rocket in 1981 after his first attempt at a commercial rocket blew up in an ignition test (see "California Rocket Race," December 1987/January 1988). Appropriately named Phoenix, his single-stage idea was designed as

a tourist spaceliner for Society Expeditions, a travel company based in Seattle, Washington. That project never got off the ground either.

Helping Hudson on the Phoenix design was a bombastic genius named Maxwell Hunter, who had his own concept for a single-stage rocket, the Spaceship Experimental, or SSX. Hunter pitched his idea tirelessly to nearly all the NASA centers, the Air Force, and the Defense Advanced Research Projects Agency until General Daniel Graham heard a Hunter briefing and convinced the Strategic Defense Initiative Organization to support feasibility studies. Today four aerospace firms are competing to design the SSTO rocket for the SDIO. General Dynamics and McDonnell Douglas are both working on a vertical-takeoff-and-landing scheme, Boeing is taking a horizontal-takeoff-and-landing approach, and Rockwell International's entry will take off vertically and land horizontally. (SDI has a seemingly inexhaustible appetite for new boosters. Not only did it provide the impetus behind the Air Force's search for the ALS and a safe haven for the SSX, it is also behind the development of a nuclear-powered rocket, code-named Timberwind. Powered by fission, Timberwind is supposed to loft up to 70 tons into low earth orbit. The project had been kept top secret, presumably because of the controversial nature of a nuclear-powered vehicle. In April, however, members of the Federation of American Scientists blew the lid off the project.)

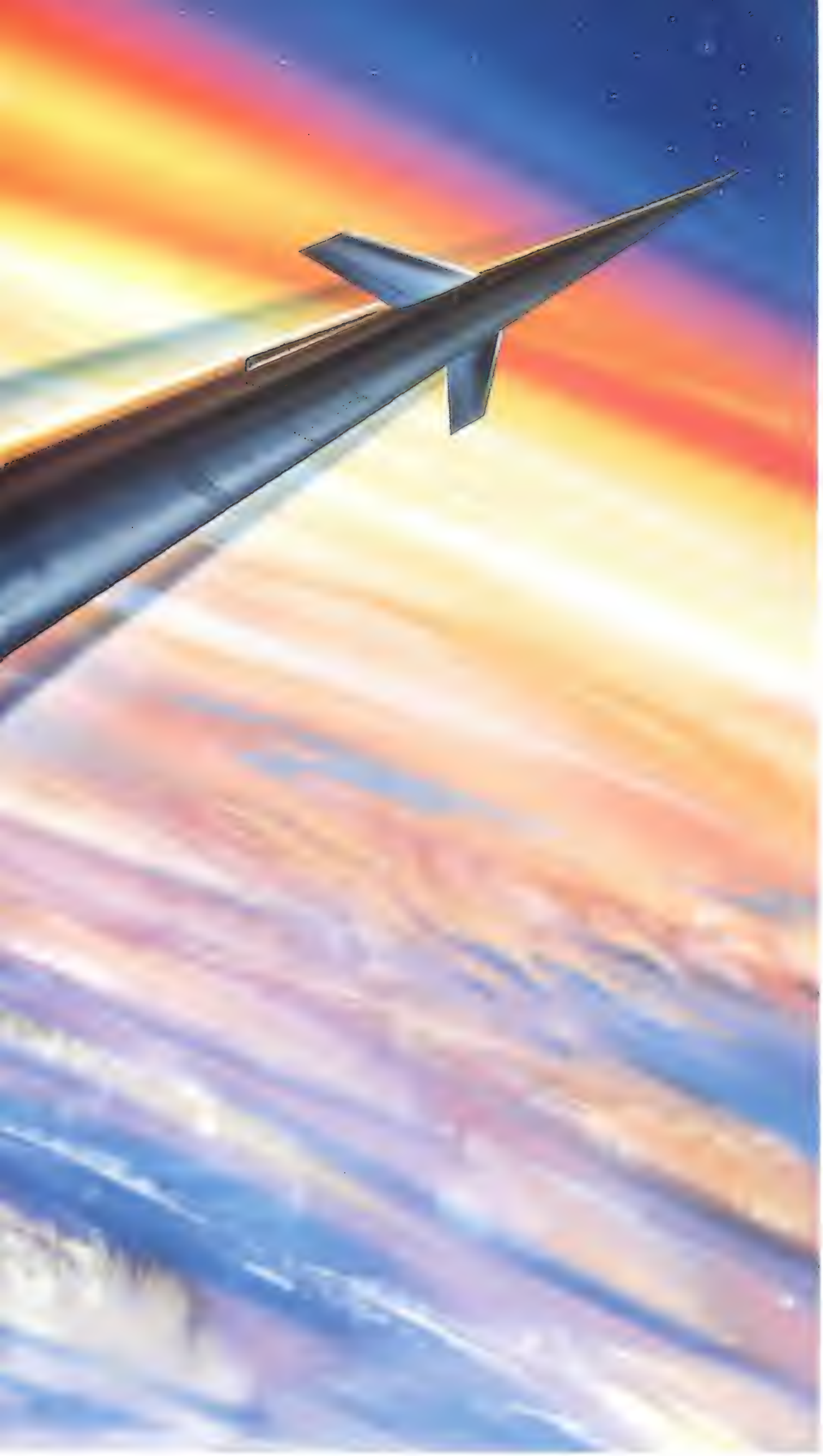
The SSX's roots in a tourist transport scheme explain its designed ability to save itself. "In the transportation business, the ability to almost always *save* not only the crew and payload, but the *entire vehicle* in case of even very severe problems, is a central paradigm," Hunter explains in his written briefing on the SSX, which is *filled* with points of emphasis. "Unfortunately, all space rockets spawn from the ammunition paradigm, since only rockets could make it to orbit when Sputnik called. The NASA 'man-rating' procedures are really a very expensive, understandably neurotic,

The NLS could be topped by an HL-20 "taxi" that could send and return astronauts to and from a space station.


NASA

method of creating *man-rated ammunition.*" Hunter's spacecraft and the single-stage rocket designs it inspired can save themselves because they have extra engines. If a failure does occur, the vehicle can still hover until it burns out its propellants and lands safely.

Dan Heald, who manages General Dynamics' SSTO project, says the technologies for a vertical landing have been demonstrated in various ways. During reentry, the rocket will use its back end as a heat shield, the same blunt-body reentry used by the Mercury, Gemini, and Apollo capsules. It will make a soft landing using retrothrust, as the Apollo lunar module did to land on the moon. "Of course there were no winds on the moon to knock you off course," Heald admits. But computers will direct the engines to compensate for wind.



The spaceplane's significant technical challenges indicate that it's too soon to retire rockets.

Had it not been for the National Aerospace Plane, the SDIO would not have been able to plan a demonstration flight for a single-stage rocket for 1995. Sophisticated materials developed for the X-30 are extremely lightweight and heat-resistant, which makes a combination of single staging and blunt-body reentry feasible. Still, to make that 1995 flight, Heald says, a lot of substitutions will have to be made. "Many NASP materials are in the lab," he says. "You can get one square foot, but you can't go out and buy 1,000 square feet. I personally would love to see another year of technology development."

Like its multi-stage brothers, the single-stage rocket can proceed only as far as its propulsion system will take it. The aerospike or plug engine, which was one of the propulsion concepts proposed 20 years ago for the space shuttle, is being revived. In one configuration, high-speed, high-pressure gases exit a doughnut-shaped combustion chamber onto a central cone, or spike, to produce thrust. Unlike the conventional bell-shaped nozzle, the aerospike nozzle has no outer wall. The engine relies on atmospheric pressure to control the flow of exhaust gases and therefore automatically compensates for increasingly lower atmospheric pressure at higher altitudes.

The single-stage-to-orbit rocket seems to inspire a little more excitement in the teams who are working on it than the conventional aerospace program does. Maybe that's because it's such a long shot, and maybe that's because it has attracted people like Maxwell Hunter who disdain the herd mentality of traditional aerospace programs. "If it is made a 'national program,' *forget it*," Hunter writes. If it is to succeed, he says, "It must go off in the desert and do its thing, a program of frankly reckless risk and perhaps even an object of ridicule. We are out to save the bureaucracy from itself...."

"It reminds me of years ago when we started work on the Atlas," says Dan Heald. "Nobody thought you could build an ICBM that would go 5,000 miles, but we just did it. It was really fun. Everybody was kind of pulling together and was worried more about making progress than about making a mistake. And that's the way it's been on this program."

The Light and the End of the Tunnel

In all the systems described so far, the payload, the only thing you really want to put into space, is a tiny fraction of the weight of its carrier. Think of the money you could save if you didn't

have to launch a big hunk of machinery every time you wanted to orbit a relatively small satellite. That's what Jordin Kare thought when he evolved his four-P philosophy. "All the hard stuff stays on the ground," says Kare. "You launch Payload, Propellant, Photons—Period."

Kare would do that with ground-based lasers, based on a concept described by Arthur Kantrowitz in 1972. A series of pulses from the lasers would evaporate and heat a propellant—perhaps something as simple as ice—aboard the payload container. The expanding propellant would push the vehicle up; repeated pulses would get it into orbit. Kare estimates that with a power supply of 150 megawatts for a carbon dioxide laser, he can more than double the annual launch capacity of all the U.S. systems—Atlas, Delta, Titan, shuttle—put together.

Ram accelerators could shoot cargo into orbit, but the G forces would be too great for humans.

At the University of Washington's aerospace and energetics research laboratory, students and faculty are taking another approach to cheap access to space. With funding provided by the Air Force, they have constructed a ram accelerator, a 52-foot gas-filled tube with a 1.5-inch bore, through which they accelerate small projectiles. Using continuous explosions that occur throughout the length of the tube, the lab has accelerated projectiles to speeds that would be the equivalent of Mach 8 in the atmosphere.

The tube is made of very high quality steel. "That's because this is a university," says Abraham Hertzberg, a physicist who directs the research program, "and I have an agreement not to kill any tuition-paying students." But even high-quality steel has its limits, and Hertzberg thinks they've gone about as far as they can go with this system. However, he eventually hopes to construct a 2.4-mile accelerator that could launch payload canisters weighing one metric ton. The payloads would have to be "acceleration-insensitive," however, since they would undergo a force at least 1,000 times that of gravity. This eliminates the possibility of sending humans, but the system could be used to resupply the space station by sending canisters of water, clothes, or an astronaut's income tax forms.

"If we had to sell this experiment now," Hertzberg told a National Institute of Standards and Technology conference in November 1989, "we'd get 50 cents and a cup of coffee." But if experimenters like Hertzberg and Kare can move their ideas out of the lab and into the market, the shuttle's replacement may not be a rocket at all.

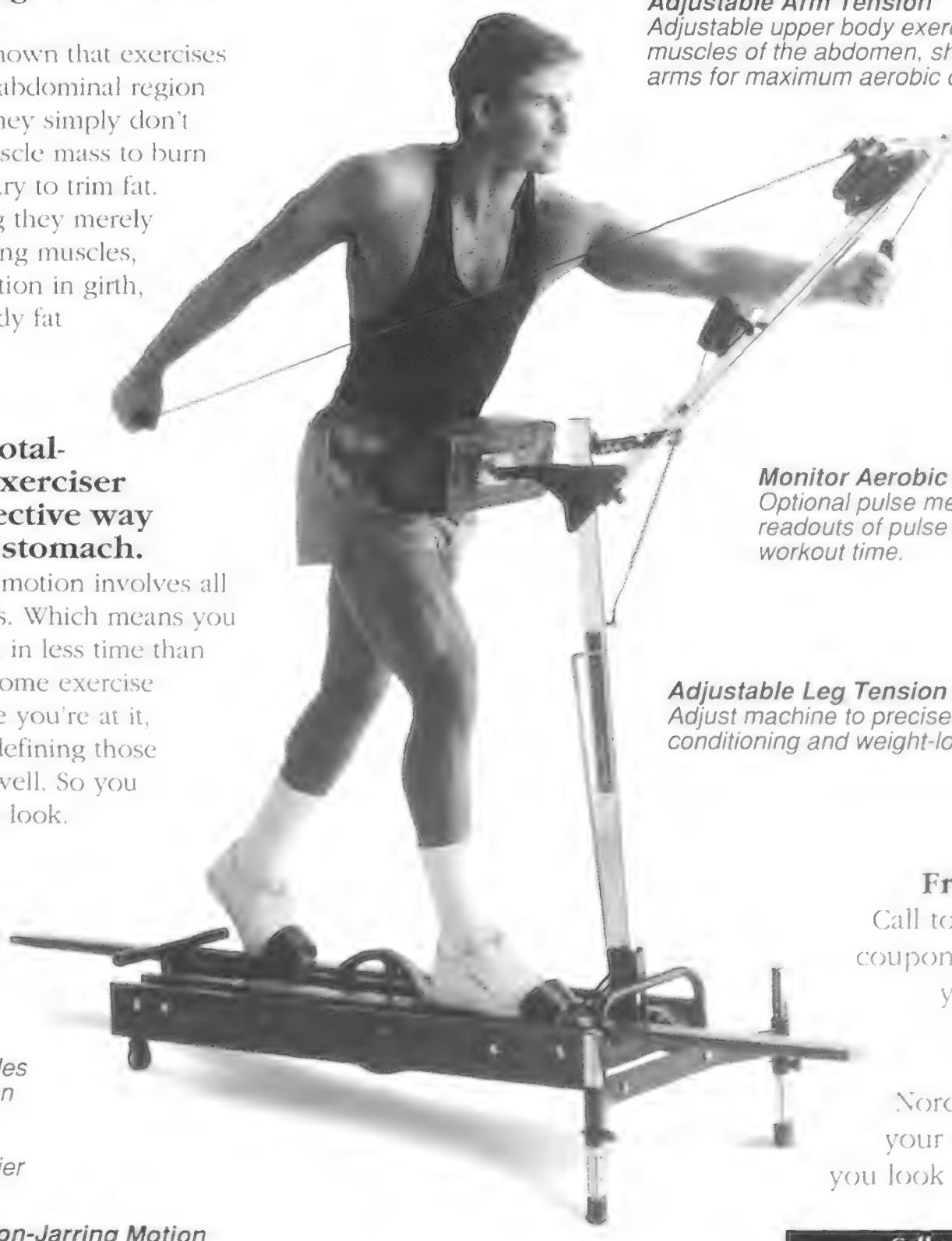
Why it takes legwork to flatten your stomach

You can't reduce stomach fat by exercising abdominal muscles alone.

Research has shown that exercises that work only the abdominal region are not effective. They simply don't involve enough muscle mass to burn the calories necessary to trim fat. Instead of flattening they merely strengthen underlying muscles, providing no reduction in girth, fatfolds, or total body fat percentage.

The exclusive NordicTrack® total-body aerobic exerciser is the most effective way to flatten your stomach.

The total-body motion involves all major body muscles. Which means you burn more body fat in less time than with any other in-home exercise machine. And while you're at it, you're toning and defining those muscle groups, as well. So you feel as good as you look.



Adjustable Arm Tension
Adjustable upper body exerciser works the major muscles of the abdomen, shoulders, back and arms for maximum aerobic conditioning.

Electronic Feedback
Speedometer displays elapsed workout time, speed, and distance traveled at a glance.

Monitor Aerobic Efficiency
Optional pulse meter provides digital readouts of pulse rate and elapsed workout time.

Adjustable Leg Tension
Adjust machine to precisely meet your conditioning and weight-loss requirements.

Patented Flywheel
One-way clutch mechanism provides continuity of motion making vigorous exercise more pleasant and easier to sustain.

Non-Jarring Motion
Smooth, jarless aerobic motion ensures maximum workout efficiency while minimizing the risk of injury to knees, shins and back.

Adjustable Legs
Raise the front of the machine to intensify workout

Free information.
Call today. Or fill out the coupon below. We'll send you a free brochure and video that describe how NordicTrack can flatten your stomach and make you look and feel your best.

NordicTrack®
A CML Company

Call or Write for a FREE VIDEO & Brochure

1-800-328-5888 EXT 113F1

❑ Please send me a free brochure
❑ Also a free videotape ❑ VHS ❑ Beta

Name _____
Street _____
City _____ State _____ Zip _____
Phone ( ) _____

NordicTrack, Dept #113F1,
104 Peavey Road, Chaska, MN 55318

Illustrations by David Moore

by Stephan Wilkinson

The Hammer strides in from his final F-16 mission, flat stomach accentuated by the elastic of his G-suit, boyishness gone from the crow's-footed eyes and hard mouth.

"Gonna re-up?" his flight leader asks.

"No, Barbara wants to settle down. I've been in the fighter business long enough."

"Then I better give you this," flight says, handing his ex-wingman an envelope. The pilot cracks a grin as he reads the return address. It's a bid to come join a pilots-in-training class at the major airline where he'll continue his career, stepping straight from the cockpit of his F-16 Fighting Falcon into that of a 737 Fat Albert.

Such was the essence of a recent TV commercial for a major airline. Indeed, any of the world's airlines would like its passengers to think they're in the hands of high-timers with matchless experience acquired in their country's fastest fighters and biggest bombers.

For many airlines, however—particularly U.S. airlines, which have had the world's richest bank of military air forces to draw upon—the demand for pilots grows while the post-*glasnost* military shrinks. No longer can the airlines assume that Uncle Sam will handle not only flight training but the trial-by-fire process through which the military has traditionally weeded out the uncommitted and the inept.

For airlines in countries with comparatively small air forces—most Third World nations and even such industrialized societies as Germany, Japan, and Britain—the situation has existed for so long that it isn't even thought of as a problem. When you fly on Lufthansa or British Airways, chances are slim that you're riding behind a cockpit full of ex-Luftwaffe hotdogs or former Royal Air Force aces.

The Europeans, you see, long ago refined a method of training airline pilots that would shock many American passengers, particularly when they learn that the day may come when it is applied in the United States as well. Called *ab initio* (Latin for "from the beginning"), it takes nonpilots and turns them into airline pilots.

Lufthansa picks its pilots while they're still in high school and then trains them outside Phoenix, Arizona—yes, Phoenix—where they learn to fly in single- and twin-engine Beech Bonanzas and Barons. Japan Air Lines sends its neophytes to California for instruction in Piper Arrows, Beech Bonanzas, and finally turboprop Beech King Air C90s. British Airways and other lines use sophisticated lightplane academies in the U.K. And airlines from developing nations employ institutions ranging from Florida flight factories such as Embry-Riddle and FlightSafety to the University of North Dakota, in windy, barren Grand Forks.

Doogie Howser as pilot in command? That'll be a hard sell for U.S. airline marketers even if pilot shortages do reach the dimensions that industry Cassandras predict. For in few professions—

The Making of an Airline Pilot

U.S. carriers are used to drawing experienced pilots from the military. Overseas, they train pilots from the ground up. Which approach will dominate in the future?

indeed, medicine is another—are maturity, sheer experience, and physical presence as widely assumed to be the keystones of competence.

Judging from advertisements, movies, and other mileposts of popular culture, Americans seem most comfortable thinking of airline pilots as conventionally handsome men with a touch of gray at the temples, a military bearing hinting of SAMs foiled and tanks taken out, a deep-voiced mellowness that says flying a crippled A320 through wind shear is a piece o' cake compared with the unspeakable emergencies they've already experienced. The airlines, of course, know better. "You don't want to clone the traditional, straight-teeth-and-crooked-smile [fighter] pilot," says USAir's director of contract training, Michael Broadway. "For example, today we ask the ex-military pilot how much contact he's had with females in positions of authority, since he may soon be flying with one."

"Every instructor pilot knows that it's not just experience that makes a good pilot," points out Kit Darby, a first officer with United Airlines and a consultant in aviation careers. "But it's pretty hard to sell that to the public because they're uninitiated observers. All they know is that if a pilot has lived through 10,000 hours of flying, he's got to have something going for him. It's a very, very crude determination of a person's survivability, that's all."

Still, much of air travel's outward appearance seems aimed at keeping that myth alive. Pilots don't wear uniforms and insignia because they're stylish but because passengers need to be reassured that their fate is in the hands of a highly disciplined, quasi-military officer corps. And it's a good bet that flight crews leave cockpit doors open while on the ground not for ventilation or because they enjoy having people peer over their shoulders but because it's good PR to give the passengers a glimpse of that complexity—"all those dials and gauges!"—so they can feel reassured that only superhumans could possibly deal with it.

But in many parts of the world, reality intrudes in ways that might surprise the mythologizers. For airline pilots are not all hatched from the same nest of eggs.

At the IASCO JAL Flight Training Center in the Napa County Airport, the student pilot lounge looks much like any other California airport rec room frequented by young pilots between flights: dog-eared aviation magazines, a bathing suit calendar, several shelves of model World War II airplanes. But the calendar belongs on the wall of a sushi bar rather than in the pages of *Sports Illustrated,* and there's something odd about the little plastic models: the dusty Hellcat, P-51, and Corsair are half hidden on a bottom shelf, while in proud view on top are a lovingly detailed Aichi Val, a Nakajima B5N2, a Raiden, and a Zero.

This is the home of Japan Air Lines' ab initio training facility, which the U.S. company IASCO has operated for JAL since 1970. Every single pilot for the Japanese flag carrier learns to fly here amid the industrial sprawl just south of California's wine country.

Unlike cockpit-crazed Americans, few of these young men would dream of sacrificing a vital body part to be an airline pilot. There is little opportunity for youngsters to become aviation enthusiasts in Japan, virtually no private aviation, no "kid at the airport fence" tradition. (The same is true in Spain, Saudi Arabia, Singapore, Egypt, Brazil, and a number of other countries that have perfectly respectable airlines.)

Instead, these future 747 captains—perhaps even hypersonic "Orient Express" skippers—were wooed by JAL recruiters who came to the candidates' colleges

to do battle with counterparts from Sony and Sumitomo, Toyota and Mitsubishi. These baby four-stripers were won over by pensions, benefits, security, and company ethos rather than the lure of a fistful of throttles. If learning to fly was part of the deal...okay, they'd learn to fly.

How does IASCO Napa differ from the hundreds of other flight schools in California, aside from the fact that all its students are Japanese? "We're a lot tougher," says operations manager Daryl Haverstick. "You walk into any other flight school and announce 'I'm gonna be an airline pilot' and they say 'Yeah, right, sure you are. First you're gonna be a private pilot, then you're gonna work as a flight instructor, then you're gonna fly air taxi....' We know [our] guys are going to go straight into the right seat of a 'Four-Seven."

In the bowels of the building, a young Japanese wearing fingerless bicyclist's gloves palms the yoke while shooting an engine-out instrument approach in a King Air C90 simulator. The grizzled American instructor—a retired military pilot—is sitting in the jump seat behind him. "Ya wanna come down faster 'n 'at," he rumbles. "Yer over the VOR awready. What's yer MDA? Ya can't come down 500 feet a minute, ya don't have room fer that."

No effort is made to speak slowly or enunciate carefully for the baffled student, who is learning to comprehend English at the same time he is learning to fly. It is one of the reasons JAL and dozens of other lines come to the United States and Britain for ab initio training. English is the international language of aviation, and the faster neophyte airline pilots are forced to learn it, the better.

The Pacific Rim may become the world's largest consumer of made-to-order airline pilots, for brand-new airlines are sprouting from the soil of economic growth. IASCO, for example, is also training dozens of Chinese novices to become pilots for Eva Airways, a rich Taiwanese airline that didn't exist yesterday but tomorrow will be operating a fleet of factory-fresh Boeing 767s, 747-400s, and ultra-long-haul McDonnell Douglas MD-11s throughout the world. Most of their pilots will be as squeaky-new as the airplanes.

"In the United States, you have a supply of pilots because they undertake and pay for their own training," points out K.T. Hoe, the Taiwanese supervisor of Eva Air's IASCO flight training program. "But a properly structured, intensive ab initio training program can turn out a much better pilot. It costs more, but you can direct the training for exactly the pilot your company wants."

Will the same methodology someday be applied to the job of creating U.S. airline officers? The answer depends on when the pool of qualified applicants dries up—a day U.S. airlines are generally united in feeling will never come.

"There are plenty of pilots. They're out there somewhere," says USAir's di-

"A properly structured, intensive ab initio training program can turn out a much better pilot. It costs more, but you can direct the training for exactly the pilot your company wants."

rector of flight administration and ground training, Richard J. Piper. "And if another big carrier meets its demise—and I suspect one will—we'll add all kinds of highly trained people to the system. I'm not aware of a single [domestic] airline committed to a 'let's grow 'em ourselves' philosophy. I don't think we need such radical approaches. There's still a very large pool out there of qualified pilots."

Others add the numbers differently and argue that the pool is already half-empty, not still half-full. "You've got to realize you're dealing with people who have been able to crack the back door, whisper the word 'pilot,' and be overrun by a horde of eager applicants," consultant Kit Darby points out. "When you do that for 20 years, it's hard to believe that the climate has changed, but there is a developing shortage [of pilots]. The qualifications that airlines accept today have been modified noticeably lower to accept a broader group of people. They're hiring pilots with less formal education. Taller, shorter, fatter, wearing glasses, with less flight time. They didn't do that because they wanted to. It was forced upon them by the supply-and-demand situation."

U.S. airlines became a mass transit system in the mid-1960s, and airline hiring immediately surged. But since Federal Aviation Administration regulations require airline pilots to give up their cockpit seats at age 60 (65 for flight engineers), the mid-1990s through the year 2000 will see a flood of retirements—probably four times the 500 to 600 captains who currently retire from the major airlines each year.

"If we don't start planning a feeder system now, we're going to get to 1995 and start wringing our hands and scrambling," says recently-retired Delta Airlines captain Henry Duffy, a former president of the Air Line Pilots Association. "If we continue to simply muddle through, the new entrant pilot coming to the airline is going to be less qualified."

By that time, our own air forces will also be smaller, with not only fewer pilots but fewer highly sophisticated, enormously expensive aircraft. Of the chosen few, the government will be able to ask greater enlistment commitment. Concurrently, the nation's second traditional source of journeyman pilots—general aviation, in which young pilots build time by flight-instructing and flying charters and light cargo—may have severely atrophied, a process well under way today.

Hard as it may be for airline publicists to deal with, this sounds like a job for Ab Initioman, the Instant Airline Pilot. U.S. airlines, long accustomed to selecting the best of the brightest, don't like the idea.

John D. Odegard, dean of the University of North Dakota's Center for Aerospace Sciences and a leading exponent of ab initio training, rolls his eyes. "When we have an international meeting to discuss the need for ab initio training, the U.S. airline people invariably say, 'What are you telling me—that we're going to have 500-hour airline pilots? Nobody's ever going to accept that. Besides, who in the world knows if you can train somebody to be an airline pilot in 300 to 500 hours?'

"The Germans stand up and say, 'Whereinhell you guys *been*? We've been doing this for 40 years. That's where *all* our pilots come from.' They've got about 310 hours when they're a fully checked-out copilot in a 737. Everyone in the world, essentially, has been doing ab initio training except the United States, because we've always had such a big general aviation system that we could hire crop-sprayers and mail pilots and flight instructors with thousands of hours."

The University of North Dakota operates perhaps the most sophisticated ab initio airline training program in the world.

"We already have an ab initio system in this country. It's just called Army-Navy-Air Force-Marines. They do exactly what the airlines are contemplating."

No newcomer to the flight training business, UND has graduated college students with FAA commercial licenses for decades, preparing them for a variety of careers in the aerospace business. "The people we produced were excellent pilots," muses John Odegard. "They had excellent skills and were wonderful instrument pilots. But they didn't know anything about being an airline pilot: how to operate as part of a crew, how to communicate as a team, jet aerodynamics, upper-level weather, oceanic weather, all the things that weren't covered in the normal program."

Good academics that they were, the UND folk defined their new ab initio program, called Spectrum, by making a list—a computerized "task analysis" of the 30,000 separate acts that make up every airline flight, routine or not. The classic student pilot spends hours making endless cross-country solo flights, learning to deal with being lost and lonely, learning how to be self-reliant. But modern airliners aren't flown by solo pilots. And self-reliance may be increasingly counterproductive in an era of "cockpit resource management," in which airline crews are drilled to take full advantage of one another's knowledge and abilities rather than honoring the traditional captain-knows-best hierarchy. So the only time a UND Spectrum student ever flies alone for course work is during his or her "first solo" and several solo cross-country flights, and only because they are FAA requirements for the first step, a private pilot's license.

To UND's disappointment, so far the only customers for the Spectrum program have been foreign lines, among them China Airlines of Taiwan and the Bahrain-based Middle Eastern carrier Gulf Air. "No domestic airline is ready to support a program like this," complains Kent Alm, an ex-Learjet captain and former college president who was the initial developer of Spectrum and is today the director of program development for the university's Center for Aerospace Studies. "Their source of pilots is the regional airlines, and as long as they have the regionals, why should they pay for something like this?" (It costs about $80,000 to send each student through the full Spectrum program, which includes 300 hours of flight and simulator time and 1,005 hours of classroom instruction.)

Even if ab initio training does become an increasingly important source of cockpit crews, one thing is clear: nobody needs to fear that it will create a corps of Nintendo-qualified motorpersons with none of the right stuff. International airlines with splendid safety records and unassailable tradition have proved that highly competent pilots can be manufactured from nonpilots.

And as consultant Kit Darby points out, "We already *have* an ab initio system in this country. It's just called Army-Navy-Air Force-Marines. They do exactly what the airlines are contemplating: take a nonpilot with a four-year degree, put him or her through an intensive flying and academic program and then into the most sophisticated airplanes in the world after only a year or so."

Few of the pilots who blew away Saddam Hussein's air force and armor had enough flight hours in their logbooks to rate as more than neophytes on any domestic trunk carrier. Yet they handled chores far more demanding than busing sales reps to O'Hare.

Besides, airplanes—and the skills they demand—are changing. No longer is it important that a pilot have 20/20 vision, a requirement that dates back to the days when eyeglasses could become filmed with oil in an open cockpit. No longer is physical strength necessary, when electrons transmit fly-by-wire commands and even back-up control systems are power-boosted. Years ago the challenge was to learn how to muscle a sick bird with two turnin' and two burnin' back onto the ground. Today, airline pilots fly for years without an engine failure, and if one occurs, it's usually a matter of securing a few switches and filling out the paperwork. The challenge is learning the technology, not the mechanicals.

"Today you need one of these to fly," says USAir's Michael Broadway, holding up a rigid index finger. "You gotta get in the airplane and go like this." He tap-tap-taps on an imaginary computer keyboard. "In our Fokker 100s, you can't even start the engines without doing that. You can't taxi a 737-400 without doing that. It's not like an old DC-9, where you turn the key and away you go. We're going to need people who are

computer-literate."

"We've hired a lot of what we call fast-jet pilots from the RAF," says British Airways 747 captain Ian Burnett, "but funnily enough, the fast-jet pilot is not necessarily a good airline pilot. He's used to making decisions on his own, and as part of a team on a two- or three-person heavy jet, it's a different matter altogether."

"I don't think you have to be shot at to be a good airline pilot," Henry Duffy, an ex-Army aviator, points out. "If there's one advantage the military pilot has over the typical general aviation pilot, it's a more complete ground school and theory-of-flight background. These are the courses that produce a broader-based pilot, and universities can deliver just that: a broader-based pilot."

Duffy feels the answer is a national system of university-based ab initio training programs designed to turn out potential airline pilots with bachelor degrees, perhaps with additional post-graduate flight training at specialized commercial academies. Does that mean airliners of the 21st century will be flown not by crews that have logged thousands of hours and hundreds of combat missions, but by bachelors of airspace-matrix management who write papers on such topics as "Gate Apportionment in a Post-Deregulation Environment: a Keynesian Crapshoot"?

"You'll need to give them the full range of ground school, the discipline of the cockpit, the importance of procedures," Duffy says. "A knowledge of the airline industry would be nice, a course in airline economics. Principles of leadership, if you're training everybody to [eventually] be a captain. You'll want to screen out the personality misfits and people without technical aptitude. Somebody who is not computer-friendly, it wouldn't have meant a damn thing 20 years ago, but certainly now it's going to be part of his or her future. And then enough flight time to have picked up all of the basic skills."

So perhaps someday the career path to the flight deck of the future may no longer lead through the Hammer's F-16 cockpit but will cleave closely to an ideal that the University of North Dakota has mapped out in its Spectrum program, which the faculty hopes will attract the attention of pilot-hungry regional airlines.

"Eventually, what we want to do is identify [airline-bound] kids in high school. Or even junior high school," says John Odegard. "Motivate 'em to study math and physics, learn a foreign language, understand that they really need to take care of themselves physically, never touch drugs. They're prescreened by the airline in high school, then they come to a university and go through a four-year program that includes ab initio flight training, keep their grades up, take care of themselves, pass all their physicals and phase checks. And if they work really hard, there is a very lucrative job waiting for them."

Mothers everywhere will be delighted.


M
472145
HO
PETIE 3RD
HO
CRIPES A'MIGHTY 3RD

It's loud. It's tough. It's temperamental. It makes your heart pound...

MEET THE MUSTANG

A fling with the P-51.

by Ron Dick

I first felt the thrill of a North American P-51 Mustang in 1950. I was a cadet at the Royal Air Force College in Cranwell when some of our Swedish counterparts came to visit. I had seen Mustangs before, of course, but only at a distance. As an English schoolboy I had cheered them as they flew overhead, their Merlin engines in full song, on their way to do battle with the Luftwaffe. Yet this had in no way prepared me for the day when the Swedes arrived.

At Cranwell we were still struggling through basic training in the stodgy Percival Prentice, but the Swedes, it seemed, did not accept candidates for air force college until they had proved themselves in a squadron. Our visitors crossed the North Sea in a squadron of 24 Mustangs, roared in low over our heads in six flights of four, then swept upward into the landing pattern. By the time they swung into line and parked in front of us, we were breathless with excitement and envy. The Mustangs confronted us, wide-stanced and deep-chested, their smooth lines flowing elegantly from outsize propeller spinner to neat square tail. The carburetor air intakes formed small self-satisfied smiles. There was an air of refined savagery about the beasts, and I found their attraction irresistible. I resolved that I must, at all cost, fly a Mustang.

That resolution had to wait 36 years for fulfillment, when the Confederate Air Force in Texas finally made it possible. The "colonels" of that civilian organization recognized an incurable infatuation when they saw one and were kind enough to arrange a rendezvous. Eventually I was summoned to Harlingen for my P-51 indoctrination.

Before coming to grips with the stick and throttle of this big-engine World War II fighter, you must first pore over the P-51 pilot training manual. During your cram sessions you will learn that the P-51D is not as big as it looks—only 37 feet across and a shade over 32 feet long—but it is hauled along by a muscular 1,490-horsepower Merlin that grips the air with a four-bladed Hamilton Standard propeller of impressive 11-foot, two-inch diameter. You will also find that this startling combination is responsible for a series of warnings scattered liberally throughout the text. For instance, do not exceed 40 inches of manifold pressure during a preflight

Thousands of World War II pilots were introduced to the premier fighter by its engaging manual (above). Today, P-51 pilots battle only for the airshow spotlight (left).

DON PATTERSON

Though the cockpit was crammed with gauges and handles, even oversize pilots found it comfortable, if cozy.

check or you may lift the tail off the ground and nose over. Do not jam the throttle forward during takeoff because certain immutable laws of physics induce perverse effects that "will cause loss of control of airplane." (Note the conviction of the word "will"; the authors do not offer the comfort of the less certain "might.")

The section on emergencies is illuminating as well. It is good to know that with a dead engine, gliding at 175 mph in still air, the P-51D is reputed to cover 14.5 statute miles from 5,000 feet. (Not bad—a Cessna 172 at 75 mph covers only half that from the same altitude.) If you should find it necessary to bail out, the manual advises that to avoid a serious headache you should first lower your seat and duck before jettisoning the canopy.

If you ditch the P-51, the manual says, the aircraft will float for all of two seconds. For Lieutenant Franklin Bunte of the Fourth Fighter Group, it was even less than that. Hit during a strafing run against a Luftwaffe airfield one spring day in 1944, he noticed that his pants and boots were on fire. Very low over a lake at more than 400 mph, he made an instant decision to seek the solace of the water and pushed the stick forward. When he came to, the aircraft was settling on the bottom. After what he describes as an eternity, he made it to shore, grateful for both the fire-inhibiting qualities of water and the ruggedness of his Mustang.

Handbook absorbed, amble out to the flight line. Act as if you did this sort of thing every day. The preflight check—and the other checks, for that matter—may be largely common sense, but use the checklist to be sure.

The check starts in the cockpit. If you are sure of your athletic ability, you may approach from the front and use the left tire to spring lightly onto the left wing over the leading edge. First-timers, however, are usually sufficiently humble to go around to the trailing edge and use the hand-hold on the fuselage. Don't step on the flaps on the way up.

Roll back the canopy and place your head in the office. Make sure that all switches are off, the controls are unlocked, the trim tab knobs are in the neutral position, the throttle is closed, the mixture control is at cutoff, and the fuel gauges read FULL. Both the oil and coolant radiator doors should be open and the flap handle should be up. (Regardless of the handle setting, the flaps as well as the inner gear doors will be down if the aircraft has been parked for any length of time. After you start the engine and restore hydraulic pressure, they will retract.)

The external check starts at the front and moves clockwise. Note that you have a generous 47 degrees of flaps, which allows you to slow the racehorse down to a reasonable landing speed. Circle the aircraft and check all the things you look at on any aircraft, like the security of panels, attach points, and fuel caps. Stick to the list and you will catch it all. However, two points deserve special mention. Because the Merlin is a thirsty engine, gulping at least a gallon per minute, make doubly sure that both tanks are full. Remember, too, that your steed is not as young as it used to be, so be especially careful about checking for wear and tear. The Mustang flies best when nothing falls off.

Climb back up on the left wing and lower yourself into the cockpit. Adjust the rudder pedals with the lever at the inboard edge of each pedal (make sure they are set equally) and strap yourself in. Once established in the Mustang's saddle you will find that the cockpit is comfortably roomy. You can move without banging into things, yet most of the switches and levers come easily to hand.

The layout is pretty standard for a World War II fighter—trim tab controls, landing gear, flaps, throttle, mixture, and propeller pitch levers to your left; flight and engine instruments and fuel and engine switches in front of you; circuit breakers and radios to your right. Once you verify where these essential bits and pieces are, start the cockpit check, proceeding from left to right. Again, stick to the checklist and take your time, but take particular note that the fuel gauges should read 90 gallons per side.

Note the redline markings indicating the never-exceed numbers of the instruments. With the P-51D approaching its 50th birthday, you will not wish to tempt fate by probing the limits of the original operational envelope, though it is nice to know that it was once cleared to withstand a pull of 8 Gs up to 505 mph.

Even these extremes were sometimes exceeded without the aircraft breaking. Hub Zemke, the legendary Army Air Forces fighter leader, once encountered severe turbulence

at 24,000 feet while leading a formation of 479th Fighter Group Mustangs through cloud in October 1944. Several aircraft were thrown on their backs and sent spinning earthward. Zemke's wingman eventually recovered just above the trees after pulling 8 Gs at 550 mph. The leader of the second element pulled 9 Gs during recovery, and the following flight leader managed 9.6. None of these three aircraft broke anything, although the last was noticeably warped by the experience. Zemke's P-51 did not survive. It must have suffered tremendous forces in recovering from the dive. It came apart, forcibly ejecting its pilot and obliging him to finish the war in a German prison camp. He later commented that he had exceeded the structural limits on this aircraft several times on previous missions and that it was probably tired.

Preliminary checklists complete, it's time to start the engine. If the engine is cold, have the ground crew pull the propeller through at least three complete revolutions to break up congealed oil and provide preliminary lubrication.

1. Mixture control to IDLE CUT-OFF
2. Propeller control full forward
3. Open throttle no more than one inch
4. Select left fuel tank
5. Battery switch ON
6. Check that area around propeller is clear
7. Fuel booster pump ON
8. If engine is cold, primer switch ON for four to six seconds
9. Engage starter
10. Let four propeller blades swing by, then ignition switch ON
11. As engine fires bring mixture up to NORMAL and the throttle to 1,300 rpm

It is difficult to keep your mind in gear the first time you sit behind a Merlin as it wakens from its slumber. It is not a gentle process—the whole aircraft shudders, the engine clatters furiously, the exhaust stacks bark, and your heart leaps into your throat. Within a few moments, however, the Merlin settles down to a smooth earthy rumble and you can resume breathing.

Modern jet engines may offer power-to-weight ratios undreamed of in the 1940s, and they may drive their airframes faster and higher than any Mustang ever could fly, but they are dispassionate creatures with no soul. The thin whine of a jet engine as heard from the cockpit does nothing to move the spirit, and these days they run their own starting sequences, checking their systems as they go. After pushing the start button, the pilot is superfluous.

Piston engines, on the other hand, have character. It is difficult to start large piston engines without becoming emotionally involved. Each must be spoken to as an individual if it is to start at all. As you busy yourself with levers and pumps and switches, you must encourage your engine, crooning or shouting depending on its particular nature. When it responds and bursts into full-throated song, any pilot worth his salt will feel his pulse quicken.

Warm up the Merlin at 1,000 rpm or so and push in the hydraulic release handle between your shins. (This handle

BILL CRUMP

Mad about Mustangs since childhood, author Ron Dick (above) eventually met his match in the Confederate Air Force's first P-51 (below).

is pulled out after flight to release hydraulic pressure from the system and to lock the landing gear handle in the down position.) The hydraulic pressure gauge on the floor will show an increase, and the flaps and inner wheel well doors will begin to come up. Move the flaps back down, watch for a flicker on the pressure gauge, and then retract them fully.

Signal the ground crew to remove the chocks, then check the brakes as the aircraft moves forward. With the stick held aft of neutral, the tailwheel can be steered up to six degrees either way with the rudder pedals. To maneuver more sharply, unlock the tailwheel by moving the stick forward of neutral.

You will now notice just how blind you are to the front because of the monstrous proportions of the engine. All you can do is taxi like a drunken sailor, swinging the nose from side to side to see where you are going.

Before reaching the runway, you must check on the Merlin's general health. Do this run-up into the wind if possible; this is a liquid-cooled engine but it needs great gulps of air to keep the coolant cool. It can get irascible when denied the feel of a breeze in its face or if it is kept on the ground too long, and the rise of its impatience can be traced on the relevant temperature gauge in the cockpit.

1. Set parking brake
2. Check each magneto at 30 inches of manifold pressure and 2,300 rpm (maximum allowable drop is 100 rpm on right, 130 rpm on left)
3. Check the propeller by moving the control to DECREASE rpm. After a drop of 300–400 rpm is indicated on the tachometer, return the propeller control full forward to INCREASE rpm. The engine should resume its normal speed
4. Retard the throttle and set the friction lock on the throttle quadrant to prevent the controls from slipping back
5. Set fuel booster pump on EMERGENCY in case the engine-driven pump fails during takeoff

If all is well, finish the other odds and ends on your checklist (landing gear warning lights functioning, flaps up, parking brake off, shoulder harness locked, canopy closed). Set the elevator trim to "takeoff" and crank in six notches of right rudder trim out of the eight allotted to counteract the left-yawing forces incurred during takeoff. You are not supposed to try getting one of these things off the ground with the strength of your right leg alone.

Call the control tower for takeoff clearance. As you move onto the runway, check to see that it is clear of traffic. You will not be seeing it once you are lined up on the centerline.

Now you will remember all the stories about the terrors of the Mustang takeoff. Some of those who have gone before you would have you believe that you are engaged in an exercise of lunacy. After all, who in his right mind would voluntarily strap himself into a machine in which forward vision is completely obscured by a massive engine, open up to full power, and sit there while said engine tries to screw itself to destruction off the left side of the runway?

The P-51's exceptionally clean design made high-speed dives exhilarating but treacherous.

A Horse of a Different Color

The North American P-51 Mustang was the result of an audacious sales pitch by North American Aviation president James Kindelberger. In 1940 British purchasing agents asked him to build numerous P-40s as a Curtiss subcontractor—on the double, please—for the beleaguered Royal Air Force. Can't do, Kindelberger replied, but I'll build you a brand-new and superior fighter in four months. Splendid, the agents said, we'll take 320.

Kindelberger delivered on time, and the RAF, delighted with the results, renamed the North American Apache the Mustang. The U.S. Army Air Forces, however, viewed the P-51 as a somewhat foreign design and therefore not worthy of much attention. It was not until the Mustang's 1,150-horsepower Allison engine, which petered out at 15,000 feet, was replaced with the more powerful Rolls-Royce Merlin with a two-speed supercharger that the fighter's popularity soared in the States.

Some 15,000 Mustangs of various configurations were produced in the five years following the initial order. (Surely the oddest offspring was the P-82 Twin Mustang, a pair of P-51 fuselages mated at the wing and tail that looked like a mutant P-38.) After its stunning performance in World War II, the U.S. Air National Guard adopted the P-51 and took it back into combat in the Korean war, while foreign air forces flew Mustangs well into the 1950s. Eventually the dwindling supply filtered down to air racers and collectors. Today, according to the Experimental Aircraft Association, perhaps only a hundred P-51s are flying.

—Patricia Trenner


GLAMOROUS GLEN III
Y
B6
414888

Zemke once said: "In making the transition from P-38s, pilots found the takeoff the most difficult thing to master. The P-38, with its two contra-rotating props, was as steady as a rock on takeoff. The P-51, with that damn great Merlin out front, had terrific yaw when the power was poured on. If you didn't watch the directional control, you could be off the runway in a second. One of our pilots was killed on his first mission when he went off the hard into the mud during takeoff."

That huge Hamilton Standard propeller is responsible for the Mustang's predilection for roaring off to the left on takeoff. The rigidity of the turning propeller (the tendency of its axis to remain fixed in space) gives rise to precession when the plane of rotation is tilted. The downward pitching moment that accompanies the raising of the tail for takeoff is precessed 90 degrees in the direction of rotation. If the tail is raised too high and too quickly, the precession may be violent enough to exceed the capacity of the pilot or rudder to control the yaw.

You are also fighting asymmetrical blade effect, which occurs when the plane of a propeller is not at a right angle to an airplane's path. On an aircraft with a tailwheel, it therefore occurs during takeoff. The downgoing blades have a greater angle of attack than those on the other side and produce more lift, which in this case translates into thrust. And then there's propwash, which spirals back down the fuselage and strikes the vertical fin at an angle that induces yaw. And finally, torque is the airframe's reaction to the turning propeller. In effect, the airplane tries to roll in the opposite direction. On takeoff this merely means that the left tire is pressing harder on the runway than the right. (Torque's bad reputation comes from the fact that in aircraft with powerful piston engines, going suddenly to full throttle in low-speed flight near the ground can lead to an uncontrollable and usually fatal torque roll, in which the aircraft does indeed roll around the propeller.)

All these effects result in a hefty yaw to the left. All is well, however, if the pilot is ready for it.

Now that you are straight, advance the throttle smoothly and steadily until you get 61 inches of manifold pressure and 3,000 rpm. Your world is now filled with the song of a Merlin in full cry. If you were expecting a slightly louder version of the educated snarl that you hear as a spectator at an airshow, you are in for a surprise. This is a full-throated, blood-curdling, adrenaline-pumping roar that stiffens the backbone and raises the hair on the nape of your neck. Your eyes are probably the size of dinner plates, yet you cannot help but feel an uplifting of the spirit as you surge forward, accelerating into the Mustang's natural element.

It may be hard to control your emotions during your first P-51 takeoff, but it is not difficult to keep the aircraft straight. The rudder becomes effective as airspeed increases and you also have a steerable tailwheel, so don't be in a hurry to improve your view by jamming the stick forward to raise the tail. Just let it come up a little when it's ready and then hold the aircraft in a tail-low attitude until it flies off at 100 mph or thereabouts.

From the moment it gets airborne, you know that this is a pilot's airplane. The controls have the firm yet lively feel you expect of a rugged fighting machine. There is nothing flighty or oversensitive in the P-51's response: this aircraft goes where it's told, and that instills confidence.

Once safely clear of the ground, break your stranglehold on the throttle and drop your left hand to the landing gear lever, down by the left rudder pedal, and pull it inward and up. With the gear up the airplane will feel tail-heavy, so trim the nose down (the trim tabs are quite effective, so be gentle). With the airspeed rising, you can start winding off the rudder trim and come back to normal climb power settings: 46 inches of manifold pressure and 2,700 rpm. Settle into a climb at 175 mph, run your eyes over the engine temperature and pressure gauges, set the oil and coolant doors to AUTOMATIC, and turn the fuel booster pump to NORMAL.

Now take a few moments to relax the muscles in your face, which by now are stretched in a frozen grin of fearful anticipation.

At an altitude of 10,000 feet, you can safely feel out the stall. Have no fear; the Mustang won't bite. It doesn't stall

like a Cessna 172, but there is nothing vicious about it. In level flight with the throttle back, you will get a slight buffeting of the elevators some 3 or 4 mph before the stall, then the left wing will drop, often quite sharply. Once you release back pressure on the stick, the nose comes down quickly and recovery is almost instantaneous. If you persist with the back pressure the aircraft will eventually spin, so don't do it. Should it happen, the handbook says that spin recovery is normal, but it adds that recovering from a spin with the power on is impossible, so especially avoid that.

For another jolt of exhilaration, let your Mustang relive its youth as you throw it about a bit. Keeping your eyes peeled for bandits, let the speed build and pull the airplane into a tight turn. If you can stand it, keep pulling to the limit. The high-speed stall gives a very satisfactory warning buffet, and the slightest relaxation of back pressure will have the aircraft flying again immediately. Having been reassured by such gentlemanly behavior, let the Mustang have its head. (Use caution on those irresistible 500-mph dives: because the P-51's laminar-flow wings, flush riveting, clean lines, and small frontal area made it the fastest-diving fighter of its day, the training manual devotes a full nine pages to the perils of high-speed dives and compressibility.) It barrel-rolls beautifully above 200 mph, and looping is elegant at speeds of 280 mph or more, but maneuvers feel right at any speed. (Don't do any that require you to be inverted for more than

Introduced on the D model, the teardrop canopy eliminated complaints about poor rearward visibility.

DEPARTMENT OF DEFENSE

10 seconds—you'll starve the oil pump and lose oil pressure.)

Fortunately, the Confederate Air Force's Mustang lacked the fuselage fuel tank that wartime P-51s carried. According to Don Lopez, who flew Mustangs with the 23rd Fighter Group in China, "It was dangerous to attempt any but the most gentle maneuvers with fuel in the fuselage tank. The center of gravity was so far aft that even in a tight turn you'd experience stick reversal and the Mustang would snap violently out of control."

You'll notice that the Mustang will not maintain attitude if you want to fly hands-off: an agile fighter does not need a transport's stability. As it wheels, dives, and soars under your hand, you feel what a marvelous flying machine this is. There is serenity here—you are alone with an inspired combination of power and grace. You are free in three dimensions and master of your fate.

But time flies as well, and at a gallon a minute the fuel gauge soon reminds you that your excursion cannot last forever. Besides, on a sunny day the cockpit gets hotter than Hades, and the noise and vibration of the Merlin become wearing. Make sure the fuel selector is on the fullest tank, put the booster pump switch on EMERGENCY and the mixture on AUTO RICH, and bring the propeller up to 2,700 rpm. Aim to arrive over the runway's touchdown point at 250 mph with 1,000 feet of altitude, then reduce power as you turn onto the downwind leg of the landing pattern.

As you complete the turn and roll the wings level, check that your airspeed is below 170 mph before dropping the landing gear. A double thump and a green light will confirm that it is locked down. The airplane will feel quite nose-heavy now, so use the nose-up trim. Start the flaps down to half and use more nose-up trim if needed as they extend. As you turn onto the base leg, re-check that gear and flaps are down, slow to 140 mph, and aim to roll out on final approach at 250 feet or so, a quarter-mile from the end of the runway. Put down the rest of the flaps and trim the nose up to compensate. Remember that the runway will hide behind the Merlin, so straight-in approaches are not a good idea. If you can see the runway once you are lined up, you are probably not going to land on it.

If you have done it right, you are over the airport boundary at 120 mph. Unless you have to cope with a screaming crosswind, you shouldn't have a difficult time landing. Ease the throttle all the way back and bring the nose up into a good landing attitude with the wheels just clear of the ground. Sight the horizon down the side of the cowling and do your best to fly the aircraft level. Keep holding it off the runway with back pressure on the stick.

When the airplane is ready to land, it will, and you should feel the satisfying bump and rumble of a textbook landing on all three tires.

After touchdown it is all too easy to sit back and play the conquering hero. Try to remember that the flying isn't over until the propeller has stopped turning and the chocks are in place. Stay sharp and keep the aircraft straight with dabs of rudder during the landing roll. Hold the stick fully back and be gentle with those brakes when you brake. After clearing the runway, open the canopy and both radiator doors, retract the flaps, set the trims to neutral, and switch off the fuel booster pump. Now you can weave your way back to the ramp and follow the checklist to shut the beast down.

1. Propeller control full forward
2. Idle at 1,500 rpm
3. Mixture control to IDLE CUT-OFF, opening throttle as rpm drops below 700
4. Battery and ignition switch to OFF
5. Fuel shutoff valve to OFF
6. Pull out hydraulic release handle
7. Lock controls
8. All switches OFF

As the rumble dies and the blades whistle down, quietly savor the moment. Think well of yourself this day. You are now one of the chosen. You are a Mustang pilot.

North American designed the P-51 (center) after the company refused a British request for Curtiss P-40s (top).


29623
48
48

Fax From the Moon

The radio observatory at the University of Manchester in England was a wonderful place to work in the 1960s. The Nuffield Radio Astronomy Laboratories' 250-foot radio telescope, located at a quiet retreat in the Cheshire countryside called Jodrell Bank, was at that time the largest in the world. Built to study radio waves from space, the telescope was the key to many of the first discoveries in radio astronomy. It was also a great tool for eavesdropping on the U.S.-Soviet race to the moon, which appeared to be neck and neck.

Sir Bernard Lovell, director of the Jodrell Bank observatory, was well known for his public relations efforts. He had learned the benefit of good press in 1957, when the Soviets launched Sputnik and the Jodrell telescope, still unfinished and in the midst of a financial crisis, nonetheless successfully tracked the new satellite by radar. This highly praised achievement—something that the Americans had been unable to do—made the costs of completing the telescope seem less painful, and since that time Lovell managed to keep Jodrell in the news whenever possible. With each new space venture, the British press (not wishing to be left out) solicited Lovell's opinion, and he was always eager to give it. He developed close ties with both U.S. and Soviet space scientists, and the telescope was often used to track the spacecraft of both sides.

On occasion, the Soviets would simply inform Lovell of their transmission frequencies. I suspect they did this because they had no backup telescopes of their own with which to track their satellites, so they figured that if the need arose, they could at least get data from Jodrell Bank. Thus, when the Soviets launched the spacecraft that made the first successful soft landing on the moon, it was not extraordinary that Lovell knew of its intended landing and its transmission frequencies. And on February 3, 1966, as Luna 9 pitched its egg-shaped instrument capsule onto the lunar surface, Lovell was in his lab recording its signals.

RON MILLER

On that historic day, as the giant telescope slowly tracked the moon across the sky, the halls of the observatory were crowded with reporters from around the world. Most of the staff, myself included, held a cynical view of the whole event. To us it was yet another spacecraft and yet another public relations effort, with the press on hand to interview Lovell about yet another accomplishment in space. And I left the observatory that evening thinking, *So what?*

When I returned to Jodrell Bank in the morning, I found that all the reporters had left. They would return sometime in the early afternoon, though, because of an incredible development they had witnessed during the night.

The night before, one of the senior astronomers, J.G. Davies, had been listening to Luna 9's signals. Davies grew convinced that the sounds were being generated by a device known as a facsimile machine. The forerunner of today's ubiquitous fax, such machines were then used by newspapers to send pictures from one office to another. Although it was a large, cumbersome device, it could be bought "off the shelf."

Davies recognized the sounds because several years earlier he had worked on an experiment that used facsimile transmitters and recorders. The devices transmitted a picture from Jodrell Bank to a laboratory in the Soviet Union by bouncing it off the moon. When Davies identified the same beeps from Luna 9, Lovell arranged to get a facsimile machine from the *London Daily Express* and feed it the recorded signals. But the machine produced only a blank image. It appeared that Davies' hunch had not paid off.

The next day the moon was due to rise again in the afternoon, and Lovell decided to feed the signals from Luna 9 straight into the facsimile recorder. The word spread around Jodrell Bank, and while most of the staff were still heartily uninterested in this venture, I made my way to the lab where the technicians from the *Daily Express* had set up their tiny, tent-like darkroom.

COURTESY NUFFIELD RADIO ASTRONOMY LABORATORIES

British scientists intercepted the first view (portion above) from the moon.

At this point, we believed that the Soviets had also failed to receive any pictures from the moon on the first day. Many of us had watched a press conference that was broadcast from Moscow all over Europe, presumably to show the results of the Soviet moon landing. The press conference featured much talk, mainly speeches by dignitaries and cosmonauts, but no pictures.

After moonrise, we again heard Luna 9's signals loud and clear. The facsimile machine was switched on, and its drum rotated slowly as a beam of light played on the photographic film in its innards. A group of us watched anxiously. It took about two and a half minutes for the first page to emerge from the machine, and a technician from the *Daily Express* carried it into his makeshift darkroom to develop. With a breathless hush we watched him emerge from his tent. His photograph was half white and half black; nothing sensible had been received.

Dejected, nearly everyone cleared the area, expecting no further success. Lovell ushered the reporters to an auditorium where he could address them. I decided to stay because I was curious about what the technicians might try next.

The drum on the facsimile machine started revolving again. Apparently Luna 9 was transmitting a second set of signals. It took about five minutes this time, and apart from myself, the only people present were the technician developing the film, another technician sitting nearby, and one other staff member from Jodrell Bank. I heard the technician splashing the paper around in the developer and then the fixer. Finally, he stuck his head out of the tent and said something like, "We seem to have something this time."

He emerged from his tent and I quickly reached for the flap, pulled it aside, and peered into the tray of fixer. When I made some exclamations of amazement, the other two came over and excitedly looked at the photo. It showed the surface of the moon, strewn with rocks that appeared to cast rather long shadows. We discovered the next day that the pictures received at Jodrell Bank were distorted by a factor of two in one direction because the screw thread of the British facsimile recorders differed from those used in the Soviet Union. The correct print should have been made twice as wide as the photo made at Jodrell Bank. But even if the image was elongated, it was no less astounding: it was still the moon—a body that had orbited this planet, unseen this close, for five billion years.

Word soon reached Lovell, who came down a few minutes later followed by his entourage of reporters. He looked at the photograph and made some historical comments, expressing amazement at the Soviets' success. None of us thought to say something really great like "One small step for man, one giant leap for mankind"; this occurred to us much later.

Now a small hell broke loose among the press corps, even as another picture was being received. The *Daily Express* was claiming sole copyright to the photos, a claim that nearly started a riot among the other newspapers. Several scientists wondered at the propriety of any British newspaper, with the aid of a British observatory, becoming the first to publish photographs generated by the Soviet space program, while others claimed the momentousness of the event put the photos in the public domain. Lovell had to make a decision.

It would have been impossible to stop the *Daily Express* from publishing the photograph, but the newspaper obviously had no grounds for exclusive rights. After all, they couldn't have obtained the pictures without Jodrell Bank's radio telescope. Of course, the telescope would have been useless without the facsimile machine from the *Daily Express*. The solution reached was a typically British compromise, and a good one at that. The first picture received was distributed to everyone. The rest were exclusive to the *Daily Express*, which proclaimed the scoop of the century in the next morning's edition.

To this day I do not know whether the Soviet space tracking facility developed its pictures as fast as we did. Based on what we subsequently learned, we deduced that the first photograph picked up at Jodrell Bank was also the first complete one sent from the moon to Earth. If that was the case, then I was the second person (and the first scientist) to see it.

To me the most amazing revelation of this whole episode was that, despite its aggressive pace, the Soviet space effort consisted of rather uncomplicated technology. Locked into what everybody knew was a race with the Americans, the Soviets had been the first to achieve a soft landing on the moon. But in order to obtain and transmit their pictures, they had used a simple, commercially available piece of hardware, a device that you or I could have bought anywhere. They basically threw it very hard from Earth and landed it safely 235,000 miles away. The cost of the picture transmission must have been tiny, especially compared with the technology being developed by the United States. There was no way that a mere layman could decipher anything from the complex digital signals U.S. spacecraft sent from the moon, with their special encoding for transmission and subsequent decoding and computer enchancement after reception on Earth. I suspect that today there are similar differences in the ways Soviets and Americans conduct experiments.

Since that day in 1966, the moon has been walked upon, littered with Hasselblad cameras, and marked with footprints that will remain for billions of years. We have all seen dazzling pictures of these unforgettable scenes. But the clearest picture in my memory is that fresh image of an ancient surface, swimming in a newspaperman's tray at Jodrell Bank.

—Gerrit L. Verschuur

ICBM: The Making of the Weapon That Changed the World *by G. Harry Stine. Orion Books, 1991. 288 pp., b&w photos, $22 (hardbound).*

On the evening of September 8, 1944, the first V-2 struck London and the world caught a glimpse of the future. Less than a year later a single bomb obliterated Hiroshima and convinced some military visionaries that a combination of rocketry and atomic energy would yield the "ultimate weapon": a nuclear-tipped ballistic missile of intercontinental range and hypersonic speed, able to hit targets accurately and with virtually no warning. The recent success of the Patriot missile aside—its target, the Scud, was a primitive, slow-moving, short-range missile—the ICBM continues to confound efforts to defend against it.

G. Harry Stine, a retired engineer who worked in the United States' early ICBM program, shared the dream of the visionaries but not their romantic illusions. To Stine, a ballistic missile is simply a rocket-propelled artillery shell and thus of the same lineage as the slingshot and rock. But the story Stine tells of the missile's evolution from Chinese firework to megaton annihilator is a fascinating one, rich with anecdote and told in a lively, conversational manner.

The development of liquid-fueled rockets began in the 1920s and proceeded along similar lines in the United States, Germany, and the Soviet Union until the Germans pulled decisively ahead in the late 1930s under the leadership of Wernher von Braun and the pressure of impending war. By the end of World War II, von Braun's missile team had drawn up plans for a two-stage ICBM capable of hitting New York City and a three-stage rocket able to put a man in orbit—although the closest von Braun had gotten to the stars was with the V-2s that landed on Antwerp and London.

According to Stine, the United States was the real benefactor of German technological prowess. By the time the Soviets got to Mittelwerke, the underground V-2 factory, most of the missiles as well as the men who made them had been brought to the West. Despite this early advantage, Stine argues, the United States managed to lose the missile race to the Soviets due to overconfidence and a misplaced faith in Russian "backwardness."

While the United States frittered its talent and resources away on simply updating the manned strategic bomber force left over from the second world war, the Soviets leapt ahead with development of the ICBM under the leadership of Sergey Korolev, the Soviets' von Braun. Although the panic that spread through the West after the launch of Sputnik in 1957 was probably also misplaced—it turns out that the Soviets' rockets didn't work any better than U.S. launchers; the Soviets were just more adept at hiding their failures—the hysteria over a "missile gap" fueled the nuclear arms race between the superpowers. In retrospect, had America recognized the importance of the ICBM earlier, much of the post-Sputnik panic could have been avoided.

Not surprisingly, *ICBM* is strongest at what Stine knows best: the story of U.S. missile development. The book contains a wealth of detail about the people of America's rocket programs and the machines they built. Less authoritative and less convincing than Stine's insider stories are his sweeping generalizations about the Germans, the Soviets, and the course of world history. The author justifies some of these assumptions by claiming that he can "think Soviet" because he knows "the structure of their language which reflects their thinking patterns (or vice-versa)...." In fact, recent revelations by the Soviets about their ICBM program show some of Stine's material to be inaccurate or dated (see "Disaster at the Cosmodrome," December 1990/January 1991). Scholars of the subject may also be disappointed to learn that the author includes only a brief bibliography and no footnotes.

While *ICBM* offers a highly readable and entertaining insider account of how the rockets were built, those wanting to know more about the military and political decisions that produced American ICBMs might wish to look at another new book, *Ballistic Missiles in the United States Air Force, 1945–1960* (U.S. Government Printing Office, 1990) by Jacob Neufeld.

—Gregg Herken is chairman of the department of space history at the National Air and Space Museum and author of The Winning Weapon: The Atomic Bomb in the Cold War, 1945–1950.

Kitty Hawk and Beyond: The Wright Brothers and the Early Years of Aviation, A Photographic History *by Ronald R. Geibert and Patrick B. Nolan. Wright State University Press, 1991; distributed by National Book Network. 160 pp., b&w photos, $29.95 (hardbound).*

"Flight was looked upon as an impossibility," Orville Wright once wrote, "and scarcely anyone believed in it, until he actually saw it with his own eyes." This perhaps explains why the brothers thoroughly photographed their work and collected others' photographs of it, eventually amassing over 3,500 images.

The Wrights' sister Katharine modestly tied her skirts for flight.

Some, such as their "First Flight" photo, have become quite famous. But this book, assembled from a collection donated to Ohio's Wright State University in 1975 by the Wrights' heirs, solemnly celebrates more obscure images as well. It provides, as the National Air and Space Museum's Tom D. Crouch notes in the book's foreword, "the closest thing you will find to a Wright family photo album."

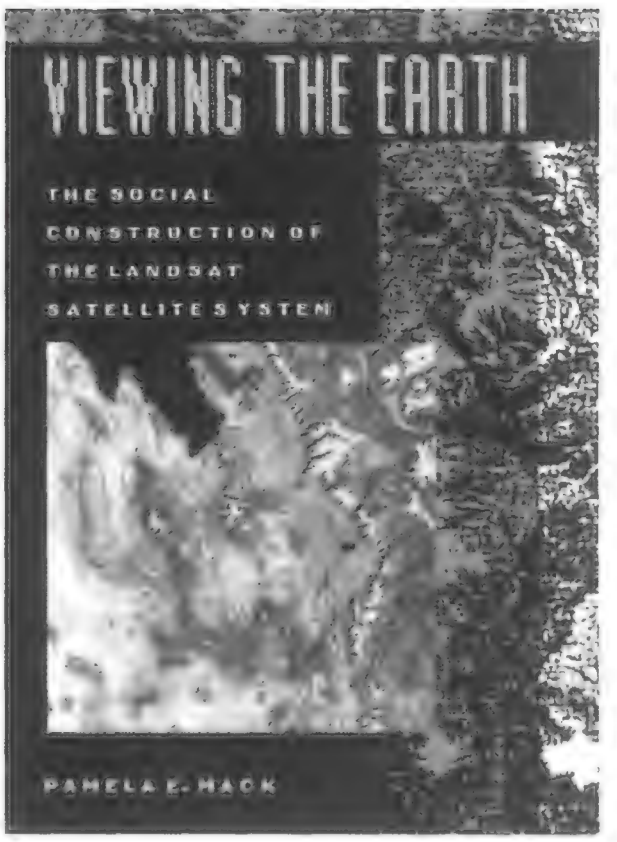
Viewing the Earth: The Social Construction of the Landsat Satellite System *by Pamela E. Mack. MIT Press, 1991. 270 pp., $27.50 (hardbound).*

NASA's much ballyhooed Landsat program has been both a great success and a surprising disappointment. On the plus side of the ledger, Landsat proved that satellites armed with a battery of sensors and cameras can monitor natural resources and help in their management. On the minus side, Landsat has never been used to its full potential, and NASA has seen its Earth observation technology surpassed by foreign satellite systems.

Viewing the Earth by Pamela Mack documents the reasons behind Landsat's success and failure. An associate professor of history at Clemson University in South Carolina, Mack succeeds in describing the political maneuvering and interagency squabbling that shaped the Landsat program and determined just how it would be employed.

According to Mack, Landsat's problems are rooted in the way NASA typically conducts business. Essentially a research-and-development organization, NASA's strength lies in the creation of experimental technologies, especially complex and expensive ones. Sometimes NASA uses those technologies and sometimes other agencies do; for instance, NASA developed weather satellites that were used and managed by the U.S. Weather Bureau. The problem is that often the target agencies require something cheaper and less sophisticated than what NASA develops.

When the Landsat program started in the early 1960s, it was to benefit users such as the Department of the Interior, which wanted to collect data about crops, forests, and the like, and private corporations, especially oil companies, which wanted to use Landsat data to select new drilling sites. Though the users advocated less-advanced technology that could be up and running quickly, "NASA managers wanted to pursue advanced technology for its own sake," says Mack.



Political maneuvering prodded NASA to accelerate the Landsat program, and it launched its first Landsat satellite in 1972. However, the agency still ran the program and generally disregarded users' recommendations and proposals. The series of experimental satellites that eventually evolved did demonstrate the feasibility of space-based earth observation technology, but the satellites and data processing facilities weren't well suited to their users' needs. Today, the project's commercial usefulness remains uncertain.

Viewing the Earth is not intended for those with just a passing interest in the Landsat program. It's targeted at people who have a serious interest in learning how our nation's space program really operates. Pamela Mack has revealed a sobering picture of the inner workings of the space agency. Whether the Landsat case is typical or unusual remains a topic for other inquiries.

—Robert G. Nichols is a science writer who contributes to Sky & Telescope, Technology Review, *and other magazines.*

Tex Johnston: Jet-Age Test Pilot *by A.M. "Tex" Johnston and Charles Barton. Smithsonian Institution Press, 1991. 304 pp., b&w photos, $24.95 (hardbound).*

There seem to be two Tex Johnstons: the one who became legendary in 1955 for performing two barrel rolls with the Boeing 707 prototype, the Dash 80, on the day of the hydroplane Gold Cup race in Seattle, and the man who, as Boeing's chief test pilot, brought to flight testing a far more meticulous approach than had ever been used before. Certainly, the company's top management had trouble reconciling one with the other. When Boeing head Bill Allen saw the barrel rolls from a boat loaded with the world's airline establishment, he asked a colleague for one of his heart pills.

In his memoir, Johnston recalls that the following day, Allen and the company's top engineers called him on the carpet for risking an airplane in which the company had invested $16 million of its own money—a gamble on its whole future in commercial aviation (see "Dash 80," April/May 1987). Johnston explained that there was no special risk since the rolls were executed at 1 G, the same force as in level flight, and that since the airplane did not recognize attitude, it "never knows it's inverted." His explanation did nothing to calm Allen, however, who later said, "It has taken twenty-two years for me to reach the point where I can discuss the event with a modicum of humor."

Johnston had a new pair of cowboy boots made for every prototype he flew; the airplanes ranged from the Bell XP-39 through the Bell X-1, the XB-47, the XB-52, and the 707. As a test pilot, he was a beguiling character, with a voice like James Stewart's, a moustache like Clark Gable's, and a seemingly inexhaustible appetite for partying. But the man of the night was always, come the dawn, gimlet-eyed with reflexes that sensed every quirk of an airframe or engine.

Johnston is of the barnstorming generation—from the days of sideslipping into a spot landing in a farmyard and stunt flying over state fairs. And the Wacos, Stinsons, and Vegas he flew are all here. In his memoir's best moments you can smell the oil on the grass. One senses, however, that between Johnston and his collaborator, Charles Barton, something got lost: Johnston's panache, perhaps, and the sharper side of his tongue.

Johnston tells, too elaborately, the story of his winning the 1946 Thompson Trophy in his hot rod P-39 but, with becoming modesty, fails to mention that he gave half of his $19,400 winnings to the widow of Jack Woolams, who was to have raced with him for Bell Aircraft in another P-39 but was killed in a pre-race crash.

Johnston is not so generous about Chalmers "Slick" Goodlin, a fellow X-1 pilot. In fact, Johnston's account suggests that Chuck Yeager might never have had the glory of taking the X-1 through the sound barrier if Goodlin had been a better experimental pilot. Johnston thought that Goodlin, a 23-year-old with combat

experience in fighters, was not technically knowledgeable enough for research flying. Eventually the Air Force took over the X-1 program, a move that Johnston says was precipitated by Goodlin's poor flying and that deprived other Bell pilots of a shot at breaking the sound barrier.

Following his six years with Bell and a spell exploring for oil in helicopters over the Louisiana swamps, Johnston joined Boeing in 1948. There, his combination of intuition and scientific insight proved invaluable.

In 1954, after the 707 prototype's second flight, Johnston reported that the airplane had a significant tendency to Dutch roll and recommended giving more attention to directional stability. But a fix that had worked earlier with the B-47—a sensor linked to the rudder that automatically dampened the yaw—didn't work for the 707. In October 1959 a Braniff 707 on a training flight got into a violent Dutch roll, threw off three engines, and crashed, killing half of the eight-man crew.

Johnston says that he was so alarmed by the crash that he insisted to the Boeing management that the 707's directional stability needed stronger medicine. The problem was finally cured with a ventral fin, at Boeing's expense—a commitment made first by Johnston on a world tour for Boeing to calm worried customers.

Soon afterward, in 1960, Boeing placed Johnston under a manager and cut him off from direct access to Allen and Boeing's headquarters. Johnston felt the change acutely and implies that he was lined up as the fall guy for the 707's problems. He quit as head of flight testing and became an assistant manager of the Dyna-Soar program in the aerospace division. In 1968, after working on Boeing's contribution to the Apollo space missions (the first stage of the Saturn booster), Johnston left Boeing.

Eight years had passed since Seattle flight control had heard his laconic, precise voice over the radio. The 707 episode was not the happiest of endings for a distinguished test flying career. Johnston had a range of experience unknown to the test pilots of today. He contributed immeasurably to the roller coaster development of commercial jets. Now, technocratic certitude has removed the Johnston breed from the cockpits. It's a safer, more decorous flight path. And duller. Much duller.

—Clive Irving is senior consulting editor at Condé Nast Traveler. *He is at work on a book about the Boeing 747, to be published next year by William Morrow.*

Credits

To England, the Long Way. Lores Bonney lives in Gold Coast, Australia.

Face-off. Alex Heard is a Washington, D.C.-based writer.

Jimmie Angel, Devil's Mountain, and the Lost River of Gold. Carl Posey's rainforest thriller *Bushmaster Fall* will be published by Donald I. Fine next year.

Camouflage. Edwards Park flew a P-39 in New Guinea during World War II. He is a frequent contributor to *Smithsonian.*

Getting Around on Mars. William Triplett wrote "NATO's Noise Problem," which appeared in the August/September 1990 issue of *Air & Space/Smithsonian.*

Sun Storms. A frequent contributor to *Air & Space/Smithsonian,* Jay Stuller wrote "The Taming of the Copter" (December 1990/January 1991).

Offbeat Landings. Chad Slattery, a photographer who freelances out of Los Angeles, spent five years collecting the photographs for this article. He photographed "The Blimp Bowl" for the February/March 1991 issue of *Air & Space/Smithsonian.*

Karen Jensen is an associate editor of *Air & Space/Smithsonian.*

Beyond the Shuttle. Linda Shiner is the senior editor of *Air & Space/Smithsonian.*

The Making of an Airline Pilot. Like many others, Stephan Wilkinson is an ab initio pilot. One day he was a groundling, the next (July 8, 1966) he'd soloed. Since then, he's logged nearly 2,600 hours and flown 130 different types of airplanes, from biplanes to business jets.

Meet the Mustang. A retired air vice marshal from the Royal Air Force, Ron Dick is a contributing editor of *Air & Space/Smithsonian.*

Further reading: *Mustang: A Documentary History,* Jeffrey Ethell, Jane's, 1982.

Fax From the Moon. Gerrit L. Verschuur is a contributing editor of *Air & Space/Smithsonian.*

A Museum of Modest Proportion. Wes Eichenwald, a Boston-based writer, has previously written for the Soundings section. He has never built a model airplane involving more than three pieces.

Calendar

June 1
Space Memorabilia Swap Meet. Holiday Inn, Laurel, MD, (301) 249-3895.

June 2
Fly-In Breakfast. Sponsored by Skyhaven Pilots Association. Skyhaven Airport, Tunkhannock, PA, (717) 836-4800.

Triathlon of Windsports. Hang gliding and stunt kite-flying competition. Jockey's Ridge State Park, Nags Head, NC, (919) 441-4124.

June 14–16
41st Annual Moonlite Fly-In. Porterville Municipal Airport, Porterville, CA, (209) 539-2506.

June 15
Aviation Safety Education Seminar. Sponsored by Pennridge Pilots Association. Pennridge Airport, Perkasie, PA, (215) 257-0166.

June 22 & 23
Quad City Air Show. Davenport Municipal Airport, Davenport, IA, (319) 285-SHOW.

June 23
Fly-In Pancake Breakfast. Bloomington-Normal Airport, Bloomington, IL, (309) 663-7632.

June 27–29
Rocky Mountain Conference on UFO Investigation. University of Wyoming, Laramie, WY, (307) 742-3399.

July 4–7
Vietnam Helicopter Pilots Association Reunion. Reno, NV, (513) 721-VHPA.

July 12–14
Northeast Stearman Fly-In. Williamsport-Lycoming County Airport, Williamsport, PA, (717) 368-3266.

July 13 & 14
Central New York International Air Show. Oswego County Airport, Fulton, NY, (315) 592-2004.

July 14–20
Aviation Heritage Elderhostel Program. University of Dayton, Dayton, OH, (513) 229-2347.

July 20 & 21
Dayton Airshow. Blue Angels, Golden Knights, and Red Baron Squadron. Dayton International Airport, Dayton, OH, (513) 898-5901.

"The Satellite Sky" Update/24

These regular updates to "The Satellite Sky" chart will enable readers to keep their charts up to date. Additions can be clipped and affixed to the chart at the appropriate altitude.

New launches

90 to 300 MILES

- Almaz 3-31-91 TT
- Cosmos 2137 3-19-91 PL
- Cosmos 2138 3-26-91 PL
- Progress M-7 3-19-91 TT

300 to 630 MILES

- Cosmos 2135 2-26-91 PL
- Lacrosse 3-8-91 VAFB
- Nadezhda-3 3-12-91 PL

630 to 1,250 MILES

- Cosmos 2125-32 2-12-91 PL

6,200 to 13,700 MILES

- Cosmos 2139-41 4-4-91 TT

21,750 to 22,370 MILES

- Anik E-2 4-4-91 KOU
- Astra 1B 3-2-91 KOU
- Cosmos 2133 2-14-91 TT
- Inmarsat II 3-8-91 CAC
- MOP-2 3-2-91 KOU
- Raduga 27 2-28-91 TT

Deletions

90 to 300 MILES

Cosmos 2033 down 1-6-91

Cosmos 2051 down 1-21-91

Cosmos 2121 down 2-10-91

Cosmos 2124 down 4-7-91

Progress M-6 down 3-15-91

Inoperative but still in orbit

300 to 630 MILES

Cosmos 2026

Launched but not in orbit

90 to 300 MILES

Cosmos 2134 USSR photo recon	2-15-91	down 2-15-91
Cosmos 2136 USSR photo recon	3-6-91	down 3-20-91
STS-37 U.S. research	4-5-91	down 4-11-91

Forecast

In the Wings...

Fate Was the Hunter. Ernest K. Gann's *Fate Is the Hunter* was published 30 years ago, and for some, the book's message still reverberates through their lives.

Planetary Weather. Forecasters have a tough enough time telling us what weather to expect on our own planet. How on Earth do they figure out what's happening on other worlds?

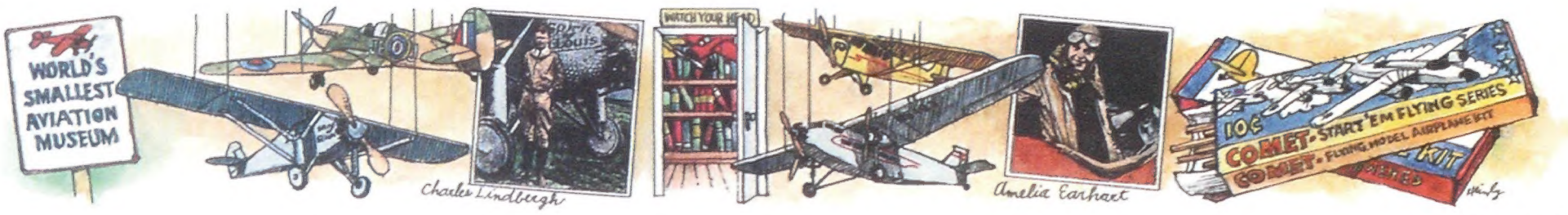
In Living Color. In our collective memory, World War II was fought in black and white. Most of the color photography of the conflict has faded by now, but Jeffrey Ethell has unearthed some pristine images that show the period in its true colors.

Housekeeping in Space. Everyone wants to know how astronauts go to the bathroom in zero G. That's only one of the problems in a world where heat doesn't rise, floating liquids form into spheres, and exhaled breath clings to your face.

Dr. Spin. When a multimillion-dollar satellite goes awry before it reaches orbit, it's time to call in the experts.

Flow Control. Why a flight delay in Chicago may be the result of a decision made in Washington, D.C.

License to Launch. Want to loft a payload? It's not all that different from registering a car. First, fill out this form...



JOHN HEINLY

A Museum of Modest Proportion

In the 1930s, when Paul Comeau was growing up in the central Massachusetts town of Leominster, he'd walk down to the banks of the Nashua River and spend hours watching airplanes take off and land at Fitchburg Airport. He also built model airplanes—lots of them.

Comeau, a trim, handsome man who appears a decade younger than his 61 years, still lives in Leominster, and the fruits of a lifelong fascination with airplanes and aviators fill a floor of his house. Comeau has proudly dubbed it the World's Smallest Aviation Museum, a title that graces an appropriately tiny sign on his front lawn. "It's nothing fabulous," he says, "just stuff I've collected over the years." Still, a sign inside cautions: "Museums should not be measured by their scope and grandeur alone. The toil and dedication of those who would see them flourish has to be considered."

The six-room museum is on the top floor of a renovated horse barn attached to Comeau's massive 1890s Victorian. After converting the carriage house into a living space, Comeau opened the mini-museum in 1986. But its origins date back to everywhere he and his wife Pearl have lived. "Sometimes the museum was here," he says, pointing to his head. "If there was room in the cellar or attic I'd put as much as I could on display. This is the biggest thing I've had, but I've still got rooms full of stuff I can't put out."

Working your way through Comeau's stuff is like perusing the National Air and Space Museum writ very small. In fact, Comeau purchased several items from the Smithsonian, like a piece of fabric from the museum's 1914 Blériot XI. He was at the new museum "not the day, but the month" it opened in 1976.

Pearl shares her husband's avocation; her oil paintings of World War I aircraft grace the third floor stairwell. The drafty rooms, with peaked ceilings, odd angles, and low doorways ("Mind Your Head" reads a sign at the entrance to the World War II Room, a converted closet), are crammed with memorabilia: posters, framed newspaper articles (like the front page of a July 1909 London *Daily Graphic* proclaiming the news of Louis Blériot's flight across the English Channel), a copy of a 1929 letter from Orville Wright to model builder Bertram Pond. The picture frames arranged on tables show not family members but Charles Lindbergh, Amelia Earhart, and Harriet Quimby. The library of over 350 volumes includes one of the few existing scripts for Howard Hughes' film *Hell's Angels.*

Above all—literally—there are model airplanes. Scores of aircraft Comeau has built over some 50 years hang from the ceiling. There's a model ornithopter built from Leonardo da Vinci's sketches, a Wright Flyer with a three-foot wingspan, a Ford Tri-motor dangling from a lamp. A red Piper Super Cruiser with a six-foot wingspan hangs in a large room filled with stacks of magazines and boxed kits.

At last count Comeau had more than 800 kits in their original boxes, some from the 1930s, some less than five years old. There are numerous models of Spitfires and of the *Spirit of St. Louis,* a Comeau favorite. Although Lindbergh made his solo flight across the Atlantic before Comeau was born, the Lone Eagle has always been a hero to him.

"I tell everyone I love aviation but I think I was born about maybe 10 years too late," he says. "I wouldn't mind being 81 and having seen some of these things transpire."

Nonetheless, he's experienced some unforgettable moments, like the time he and his family visited the 1939 World's Fair in New York. His fondest memory is not of the Trylon or Perisphere but of a Boeing Clipper landing at Flushing Airport. "The hair on the back of my head went up for about a week," he says.

Comeau's collection draws from flea markets, museums, friends, and relatives. A retired Air Force colonel contributed one prized item. When a National Air and Space Museum crew reassembled the *Spirit* after moving it into the new museum, a few tiny pieces became priceless souvenirs for the workers. "The wing root is inside, you don't see the fabric anyway," says Comeau, "so [the project leader] took the fabric out and cut it into pieces, and anybody that worked on moving it had a chance to get a piece." One small scrap of Lindbergh's airplane hangs on a wall in a room named in his honor, a homey place furnished with sofas and end tables.

Another valued item is a propeller tip from a Japanese Zero shot down over Guadalcanal in 1943. It was donated by a World War II veteran who procured the souvenir with a hacksaw. In a display case rests a small World War I bomb, the kind that aeronauts simply tossed out of their aircraft. "It's more of a head clunker than an explosive device," Comeau says.

Today the curator finances new acquisitions by selling collectibles he no longer wants and building and selling models. A hip replacement has slowed Comeau down a bit, but he still dreams of a proper air museum in Leominster. "It's not so much what you can see but what you intend to do, you know? If I live long enough, I *will* have a museum."

Still, the current setup has its satisfactions. Most of the 20 to 30 annual visitors are either fliers or aviation fans whose enthusiasm runs as high as the curator's. Comeau recalls with delight one recent visitor who was at Le Bourget field the night Lindbergh landed. "The more the merrier," he says. "I enjoy talking to anybody that wants to listen to me gab about airplanes."

To Comeau, now retired after 25 years in a toolmaking factory and a stint as Fitchburg Airport's manager, the collection is a refuge. "I tell people there are days when everything doesn't go just right and they want to get away from the real world, they go back [here] to the old days when aviation was—it's still great, but I mean, it's not what it used to be."

—Wes Eichenwald

The World's Smallest Aviation Museum, 106 Merriam Avenue, Leominster, MA 01453. Tel. (508) 534-8981. Open "basically weekends" by appointment. Admission free.

PLANET EARTH
A COMMEMORATIVE EARTH DAY POSTER FROM THE APRIL 1990 SMITHSONIAN

The Poster measures 21¾" x 28¾"
Printed on Recycled Paper
Allow 4 to 6 weeks for delivery

Send $5.00 with address to:
Smithsonian Magazine, P.O. Box 23624,
Washington, D.C. 20026-0624

"People who think flying's hard never tried stopping a 2-iron shot on a shallow green." *Arnold Palmer*

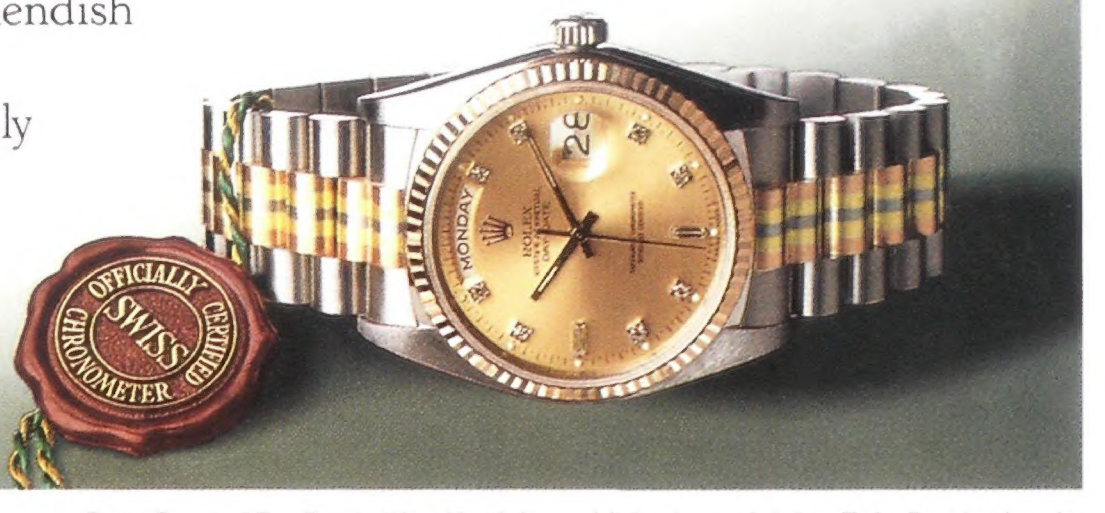
Conquests at the Masters, British and U.S. Opens, along with 61 PGA victories, have ensconced Arnold Palmer among golf's all-time greats. But Palmer's enormous impact upon his game is a triumph of personality as much as shotmaking.

Palmer is the first professional golfer a broad spectrum of American sports fans ever got very excited about. His slashing swing, and openly determined face that shared all the ups and downs of an important round, sped the emergence of professional golf as a major sport and inspired millions to take up the fiendish game.

Along the way, Palmer virtually invented the athlete-spokesman entrepreneur. That same pioneering instinct led him, more than 30 years ago, to train himself as a pilot, quickly moving up from twin-engine prop planes to sophisticated long-range jets and helicopters. "I couldn't have accomplished half of what I have without my own plane," says Palmer.

On the ground or in the air, high performance requires complete confidence in one's equipment, which may explain why Palmer has long made Rolex his favored choice of a timepiece.

ROLEX



Oyster Perpetual Day-Date in 18kt gold with diamond dial and concealed-clasp Tridor President bracelet.
Write for brochure. Rolex Watch U.S.A., Inc., Dept. 338, Rolex Building, 665 Fifth Avenue, New York, N.Y. 10022